Here begins our new MIRAI
MOONSHOT
RESEARCH & DEVELOPMENT PROGRAM

R&D Theme

Generating and controlling the air-water turbulence field with temperature gradient and surface waves at extremely high wind speeds

Progress until FY2022

1. Outline of the project

Prediction accuracy of typhoon tracks has increased in recent years, whereas that of typhoon intensities has not been improved. One of the causes is the difficulty of representing momentum and heat transfer mechanisms across the sea surface in typhoons. In particular, momentum and heat transfer across the sea surface, which substantially influences intensities of typhoons, has not been well modeled.

The goal of this project is to develop accurate models for predicting the heat and momentum fluxes across the air-water surface under high wind-speed conditions similar to typhoons, using the largest typhoon simulation tank in the world, and to suggest experimentally and numerically whether typhoons are controlled (weakened) by manipulating the sea surface conditions.

This R&D theme aims to generate pure wind-wave fields in the typhoon simulation tank, at Research Institute for Applied Mechanics, Kyushu University, and develop advanced techniques for measuring wind-wave characteristics, which are required for computer typhoon simulations. Our previous experiments have been conducted at a short fetch of 6.5 m. However, in the ocean, wind waves are generated over an extremely wide area, and so the experiments at longer fetches are needed. Our typhoon simulation tank (Fig. 1) has long fetches up to 30 m and enables to accurately investigate the wind-wave characteristics and heat and momentum transfer mechanisms under high wind speed conditions similar to typhoons. By collaborating with our other experimental and simulation groups, we are planning to explore new approaches for controlling typhoons.

Fig. 1: Typhoon simulation tank

2. Outcome so far

① Generation of typhoon fields

Using the typhoon simulation tank, we generated pure wind-wave fields at high wind speeds up to 40 m/s and fetches up to 30 m. In such high-speed winds, a lot of droplets are generated at the water surface by wave breaking (Fig. 2). The dispersed droplets tend to collide with Eastern-style pitot tubes and prevent to measure wind speeds. Therefore, Western pitot tubes resistant to droplet clogging were used here. This enabled us to measure the wind speeds with high accuracy.

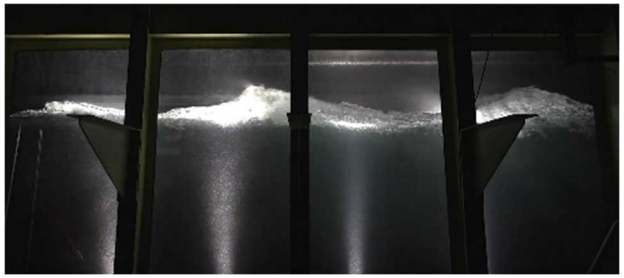

Fig. 2: Water surface with experimentally produced wind

② Measurements of wave characteristics

The characteristics of wind waves were investigated in the typhoon simulation tank. According to our previous studies, the wave height and frequency were useful for estimating the drag coefficients related to the momentum flux. Therefore, the wave heights and frequencies at various wind speeds were accurately measured using electrode wave gauges (Fig. 3).

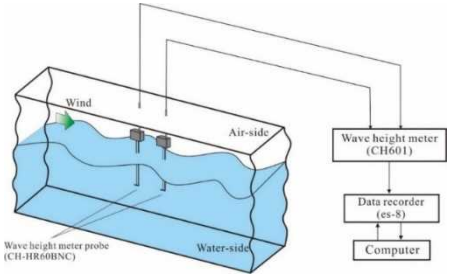

Fig. 3: Measuring wave height using electrode wave meters

3. Future plans

We will investigate whether momentum and heat fluxes across the air-water surface are controlled by manipulating the water surface conditions. This may lead to the ability to control typhoons, since the momentum and heat fluxes significantly influence the typhoon intensities. This will also allow us to provide more advanced water-surface manipulation method for changing the fluxes more effectively. If so, we will numerically confirm the potential for typhoon control in collaboration with our computer simulation group.

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