Parallel Computation of Ocean-Atmosphere-Wave Coupled Storm Surge Model

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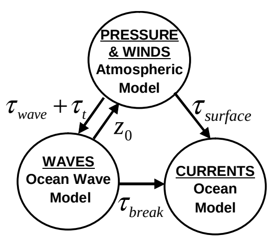
1. Introduction

Storm surges can be considered as the phenomena of mean sea-level changes, which are the result of the frictional stresses of strong winds blowing toward the land and causing the set level and the low atmospheric pressure at the centre of the cyclone can additionally raise the sea level. In addition to the rise in water level itself, another wave factor must be considered. A rise of mean sea level due to white-cap wave dissipation should be considered. In bounded bodies of water, such as small seas, wind driven sea level set up is much serious than inverted barometer effects, in which the effects of wind waves on wind-driven current play an important role. It is necessary to develop the coupled system of the full spectral third-generation wind-wave model (WAM or WAVEWATCH III), the meso-scale atmosphere model (MM5) and the coastal ocean model (POM) for simulating these physical interactions. As the component of coupled system is so heavy for personal usage, the parallel computing system should be developed.

2. Parallel coupling model

In this study, first, we developed the coupling system of the atmosphere model, ocean wave model and the coastal ocean model, in the Beowulf System, for the simulation of the storm surge. It was applied to the storm surge simulation caused by Typhoon Bart (T9918) in the Yatsushiro Sea. The atmosphere model and the ocean model have been made the parallel codes by SPMD methods. The wave-current interface model was developed by defining the wave breaking stresses. And we developed the coupling program to collect and distribute the exchanging data with the parallel system. Every models and coupler are executed at same time, and they calculate own jobs and pass data with organic system. MPMD method programming was performed to couple the models. The coupler and each models united by the separated group, and they calculated by the group unit. Also they passed message when exchanging data by global unit. The data are exchanged every 60-second model time that is the least common multiple time of the atmosphere model, the wave model and the ocean model.



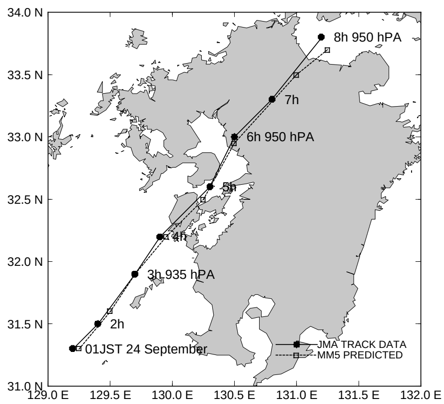


Fig.1 The track and central pressure (in hPa) of the Typhoon Bart based on the JMA track data (solid line) and predicted typhoon track (dotted line) from 09 22 Sep. to 21 JST 24 Sep., 1999

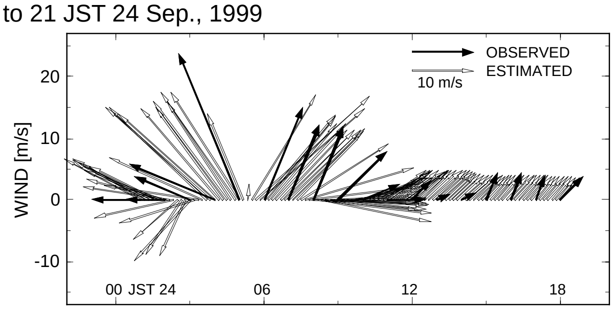


Fig.2 The observed and estimated wind vector at Yatsushiro Harbour, where the filled arrow indicates the observed mean wind speed and direction and unfilled arrow indicates the computed mean speed and direction of surface wind computed by MM5. Observed wind data is plotted every 1 hour and computed wind data is plotted every 10 minutes. Wind data observed at Yatsushiro Harbour affected by land topography of Kyushu. Contrary to the simple typhoon model, MM5 could consider realistic terrain and physical effect.

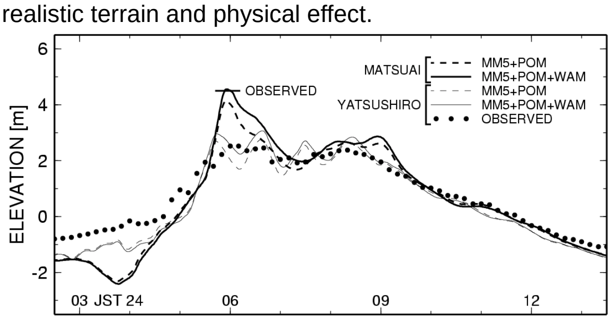


Fig.3 The model was applied to the storm surge simulation in the Yatsushiro Sea, in which we could not simulated the observed maximum surge height with the numerical model that did not include the wave breaking stress. It is confirmed that the simulation which includes the wave breaking stress effects can produce the observed maximum height, 450 cm, at Matsuai.