# Atmosphere-wave-ocean coupled-model simulation on Typhoon Bualoi(2019) and formation of quasi-linear convective system around Boso Peninsula


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## 1. Introduction

On October 25 in 2019, heavy rainfall accompanied by low pressure was observed on the Boso Peninsula (Fig. 1), causing serious natural disasters when Typhoon Bualoi was transited into an extratropical cyclone east of Japan. Although the warm and moist air transported from this typhoon is thought to be one of the factors in formation of the convection system and heavy rainfall, the relationship is not clear. In order to understand the role of the ocean in the simulations of Bualoi and formation of the convective system, numerical simulations were performed by using a coupled atmosphere-wave-ocean model (Wada et al., 2018).

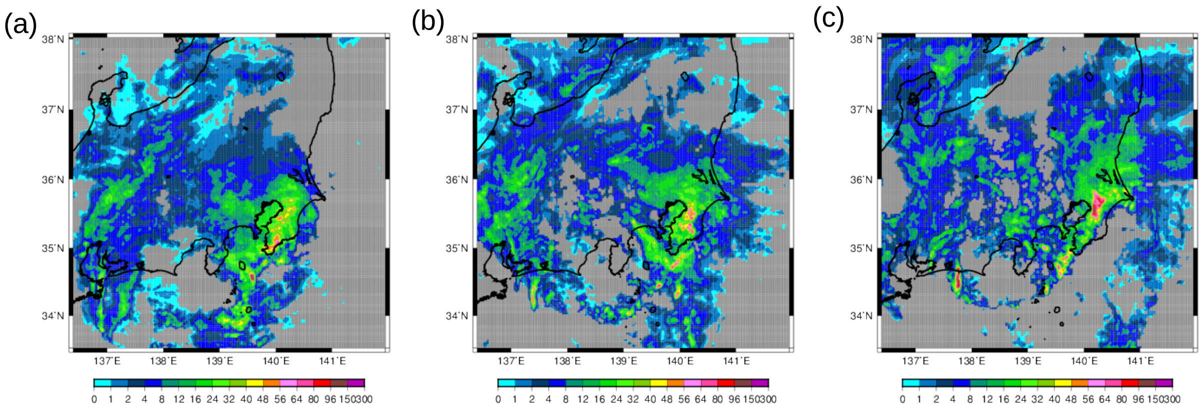


Figure 1 The 1-hour rainfall distribution analyzed every 10 minutes (mm/hour) at (a) 00 UTC, (b) 02 UTC and (c) 04 UTC on 25 October in 2019.

## 2. Experimental design

The list of numerical simulations is shown in Table 1. Each initial time was 0000 UTC on October 22. The computational domain was 2160 x 4320 km. The number of the vertical layer was 55. The top height was approximately 27 km. The integration time was 36 hours. The time step was 3 seconds for NHM, 18 seconds for the ocean model, and 6 minutes for the ocean surface wave model. The physical components were exchanged between NHM, the ocean model, and the ocean surface wave model every time step of a model with a longer time step. The Japan Meteorological Agency (JMA) global objective analysis with horizontal resolution of 20 km and the JMA North Pacific Ocean analysis with horizontal resolution of 0.5° were used for creating atmospheric and oceanic initial conditions and atmospheric lateral boundary conditions. In addition, climatological oceanic averaged data are calculated by using the oceanic reanalysis data from 1982 to 2018 (Usui et al., 2017). When the climatological data are used in the simulation, 'AVE' is added to the end of the experiment name shown in Table 1.

Table1 List of numerical simulations

| *Name* | *Model* | *Ocean* |
|---|---|---|
| NHM | NHM | 2019 |
| CPL | Coupled NHM-wave-ocean model | 2019 |
| NHMAVE | NHM | Climatology |
| CPLAVE | Coupled NHM-wave-ocean model | Climatology |

## 3. Results

### 3.1 Track and central pressure

Figure 2 shows the simulated track of Bualoi and time series of simulated central pressure with the best track data. The track was reasonably simulated. Increases in central pressure during the decaying phase was also reasonably simulated although the initial value was quite different between best track data and simulation results. The effect of

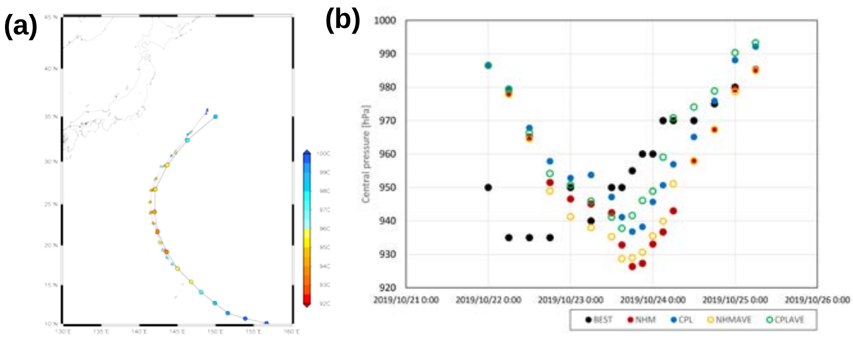


Figure 2 (a) The simulated track of Bualoi with the best track. Squares indicate the result of NHM and triangles indicate the result of the coupled model. The red line shows the result of climatological oceanic condition. The color shows the value of the central pressure. (b) Time series of simulated central pressure with the best-track central pressure.

ocean coupling and preexisting oceanic condition on the simulations was found in the values of simulated minimum central pressure and simulated central pressure during the decaying phase.

3.2 Rainfall distribution

Figure 3 shows the horizontal distributions of accumulated rainfall for 90 hours in the four experiments (Table 1). There is no essential difference between the four accumulated precipitation distributions. However, in the CPL experiment, the accumulated rainfall was higher in Boso Peninsula than in the other experiments. It should be noted that the maximum accumulated precipitation did not always decrease by ocean coupling or by the use of climatological mean oceanic initial condition in spite that they did affect typhoon intensity simulation directly.

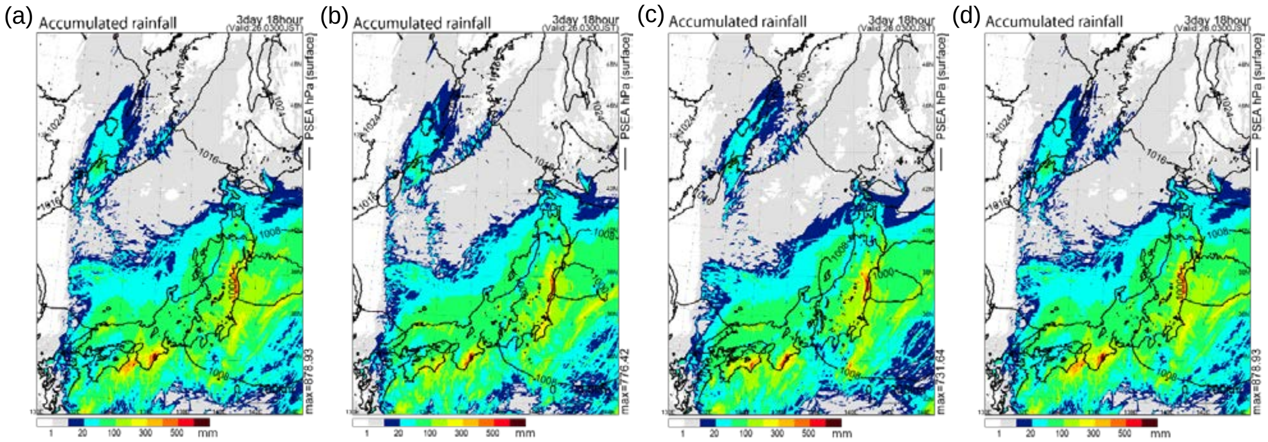


Figure 3 Accumulated rainfall distribution for 90 hours in the (a) NHM, (b) CPL, (c) NHMAVE and (d) CPLAVE experiments.

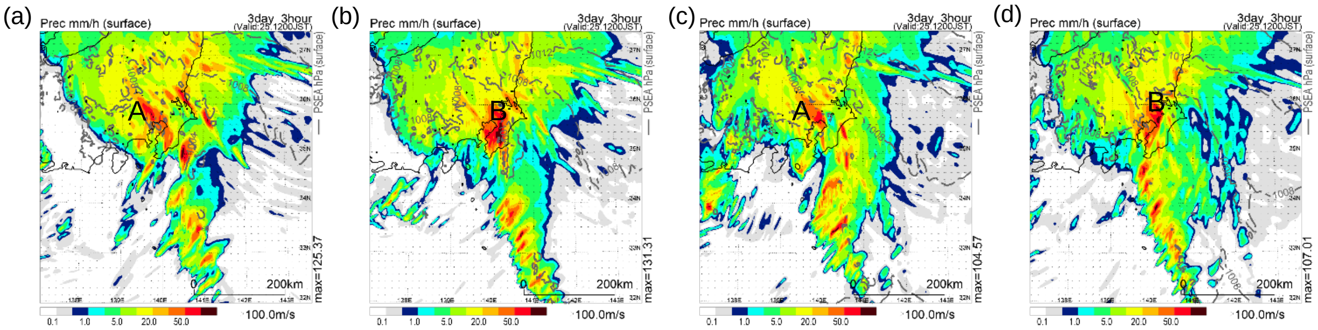


Figure 4 Accumulated 1-hour rainfall distribution (mm/hour) at 03 UTC (12 JST) on October 25 in the (a) NHM, (b) CPL, (c) NHMAVE and (d) CPLAVE experiments.

Figure 4 shows the horizontal distribution of simulated accumulated 1-hour rainfall in the four experiments. Differently from the results shown in Fig. 3, the distribution of local convective system was greatly different between the four experiments. Around the Boso Peninsula, some experiments (‘A’ in Fig. 4a,c) showed that the northwest-southeast precipitation system was dominant, while the others (‘B’ in Fig. 4b,d) showed the north-south quasi-linear convection system on the Boso Peninsula. This suggests that the ocean coupling may affect the simulation of local precipitation system caused in the Boso Peninsula although the precipitation pattern on a synoptic scale was almost the same between the four experiments.

## 4. Concluding remarks

The effects of ocean coupling and preexisting oceanic condition did affect the simulated central pressure of Bualoi and the convective precipitation system on the Boso Peninsula. In contrast, it had a small impact on the rainfall distribution on a synoptic scale. It should be noted that this result may be affected by the constraints of lateral boundary conditions that are unique to numerical simulations using regional atmosphere models.

## References


Usui, N, T. Wakamatsu, Y. Tanaka, N. Hirose, T. Toyoda, S. Nishikawa, et al, (2017), Four-dimensional variational ocean reanalysis: a 30-year high-resolution dataset in the western North Pacific (FORA-WNP30). Journal of Oceanography, 73, 205-233.

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