Super high-resolution experiment using the JMA-NHM and the K computer

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1. Introduction

In Japan, localized torrential rainfalls cause severe disasters every year. For example, debris flow in the “Izu Ohshima” island on October 15-16, 2013 has been recognized as one of the most devastating disasters in recent years. There are two observatories in the island, one is in the northern part and another is in the midwestern part near the debris flow area. The distance between two observatories is only about 4 km. However, the hourly rainfalls at the peak period (at 0300 JST, October 16) in the observatories were quite different. The hourly rainfall was 118 mm in the midwest part and 63 mm in the north part. To predict this kind of a localized torrential rainfall, a super high-resolution (several hundred meter scales) model is necessary. Many previous researchers carried out numerical experiments with higher resolutions for tornado, typhoon and heavy rain events with limited nested domains. In this study, we performed a super-high resolution (500 m) numerical weather simulation over a large domain covering thousands of km to reproduce the localized torrential rainfall using the huge computational resource of the K computer.

2. Experimental design

The case study of this research was on the Izu Ohshima heavy rainfall event on October 15-16, 2013. This study employed the Japan Meteorological Agency Non-Hydrostatic Model (NHM) and the K supercomputer. The computational domain was the same as in the previous Local Forecast Model of JMA (Figure 1) with a size of 1600 km x 1100 km. The location of Izu Oshima is indicated by a red square in Fig. 1. Table 1 shows the NHM model settings for the high resolution experiment. Initial and boundary conditions were given by the JMA Meso-scale analysis.

3. Results

We performed two experiments, with a super high resolution (HIGH: the horizontal resolution 500m) and with a low resolution (LOW: the horizontal resolution 2 km). Figure 2 shows six hour rainfall by the JMA’s precipitation analysis. Izu Ohsima was in the center of an intense rain band. Figure 3 shows observation and simulation results for one hour rainfall. In the LOW experiment, the strong rain band was simulated in the west of Izu Ohsima, and intense rain appeared in the north of the island at 0400 JST. In the HIGH experiment, the island was covered by the intense rainfall band and the strongest rainfall appeared over the area where the debris flow occurred (midwestern part of the island). The HIGH experiment captured characteristics of observed rain better than the LOW experiment. Figure 4 shows the impact of turbulence closure model on the position of the rain band. The results showed that the Deardorff scheme reduced the deviation of the rain band position in both LOW and HIGH experiments.

These results show that high resolution is important for accurate simulation of heavy rainfall. More detailed experiments are underway to see the impact of higher resolution and model domain.

Table 1. The experimental conditions. NHM parameters were selected according to model resolutions.

Horizontal resolution	Time Step (second)	NX	NY	NZ	Turbulence closure model
2 km	10	800	550	60	Mellor-Yamada level3
500 m	2	3197	2197	85	Deardorff
250 m	1	6393	4393	168	

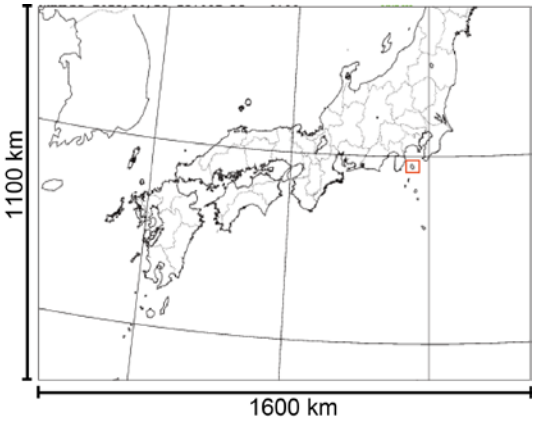

Fig. 1. Experimental domain: same as for the previous Local Forecast Model of JMA. Izu Oshima is indicated by a red square.

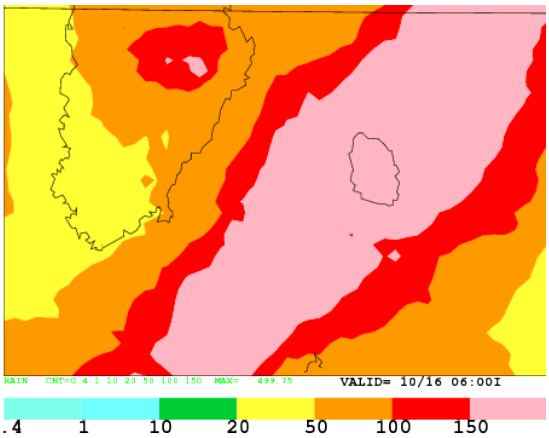

Fig. 2. Observed six-hour rainfall (until 10/16 0600 JST). The most intense 456 mm rainfall was observed in the midwestern part of the island.

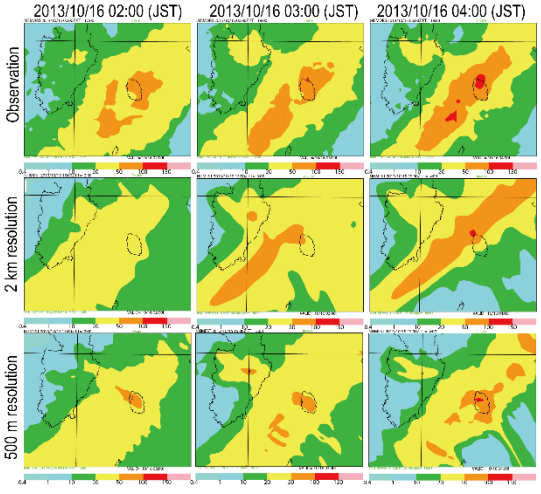

Fig. 3. Hourly rainfall from 0200 to 0400 JST by observation (upper), the HIGH experiment (middle) and the LOW experiment (bottom).

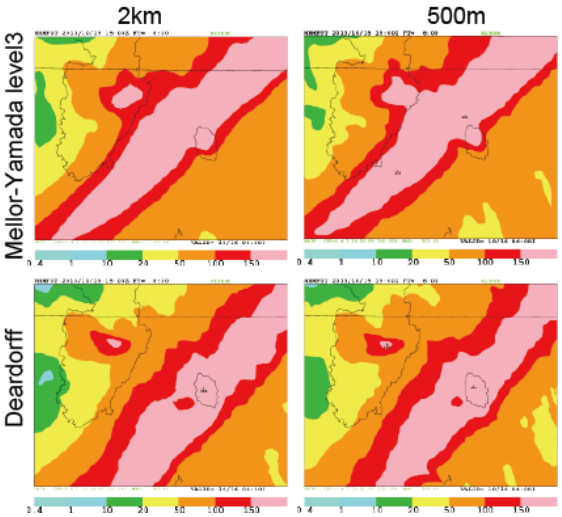

Fig. 4. Six-hour rainfall (until 10/16 0600 JST) of the HIGH and LOW experiments using the Mellor-Yamada and the Deardoff scheme.

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