Numerical simulations of intensity changes of Typhoon Man-Yi in 2013

Akiyoshi Wada*
*Meteorological Research Institute, Tsukuba, Ibaraki, 305-0052, JAPAN
awada@mri-jma.go.jp

1. Introduction

Typhoon Man-Yi in 2013 was the second typhoon making landfall in Central Japan. The typhoon caused torrential rains in front of the typhoon. Special warnings launched August 2013 were issued for three western Japan prefectures of Fukui, Kyoto and Shiga. This was the first time to issue special warnings. One of interesting features is rapid intensification south of Shikoku Island. A small eye was formed within the inner core. The falling rate of best-track central pressure exceeded 15 hPa per six hours north of 30˚N (The rate corresponds to 60 hPa per day) according to best track data archived in the Regional Specialized Meteorological Center Tokyo. The purpose of this report is to investigate the role of oceanic environments and typhoon-induced sea surface cooling in the intensity changes of Man-Yi, particularly rapid intensification occurred south of Shikoku Island by using a regional atmosphere-wave-ocean coupled model.

2. Model and experimental design

Numerical simulations were conducted by a regional atmosphere-wave-ocean coupled model developed by Wada et al. (2010). The coupled model covered a ~2000 km x ~2400 km computational domain with a horizontal grid spacing of 2 km. Hereafter, 'A' indicates the regional atmosphere model and the results, whereas 'AWO' indicates the regional atmosphere-wave-ocean coupled model and the results. Both the regional atmosphere and the coupled models had 40 vertical levels with variable intervals from 40 m for the near-surface layer to 1180 m for the uppermost layer. The top height was ~23 km.

The simulations used the Japan Meteorological Agency global objective analysis data for atmospheric initial and boundary conditions (with a horizontal grid spacing of ~20km) and the daily oceanic reanalysis data calculated by the Meteorological Research Institute multivariate ocean variational estimation (MOVE) system (Usui, et al., 2006) with the horizontal grid spacing of 0.5°, and that of 0.1° (for convenience, 'H' added in the latter part). This study also used the daily oceanic reanalysis data in 2011 in order to investigate the influence of oceanic preexisting environments on the typhoon simulations. In fact, water temperatures south of Shikoku Island in 2011 were much lower than those in 2013 due to sea surface cooling induced by Typhoon Talas in 2011. The initial time was 0000 UTC on 14 September in 2013. The integration time was 60 hours. Wad et al. (2010) described details of model and experimental design.

3. Results

Figure 1a shows the results of track simulations of Mai-Yi in A, AH, AWO and AWOH experiments and Fig. 1b shows those except that the track simulations were obtained by using the oceanic reanalysis data in 2011. Figure 1 indicates that both sea surface cooling and a difference in oceanic initial conditions do affect the track simulations north of 30˚N when both the simulated and best track typhoons underwent intensification and changed to the mature phase. This suggests that the central position of Man-yi was affected by the oceanic environmental condition from the intensification to the mature phase.

The results of central pressure simulations shown in Fig. 2 were related to the difference in the track simulations (between Fig. 1a and Fig. 1b). Figure 2 indicates that oceanic initial data do greatly affect the simulation of rapid intensification of Man-yi. In contrast, the results of the central pressure simulations did not reproduce the rapid intensification like high falling rate of central pressure found in the best track data. This is probably due to preexisting sea surface cooling induced by Talas in 2011. This implied that environmental steering flow was relatively weak compared with the effect of ocean coupling on the steering flow.

Figure 3 displays horizontal distributions of radar-amedas composite analysis of total precipitation (Fig. 3a) together with the results of numerical simulations in AH (Fig. 3b) and AWOH (Fig. 3c). Excessive rains in AH around the southeastern side of Kii peninsula were suppressed in AWOH. The result was comparable with the results shown in Fig. 3a. However, torrential rains occurred north of Kinki region was poorly simulated in both AH and AWOH although accumulated precipitation in AWOH partly exceeded 300 mm per day around the region. Changes in the oceanic initial conditions little affected the simulation of total precipitation.

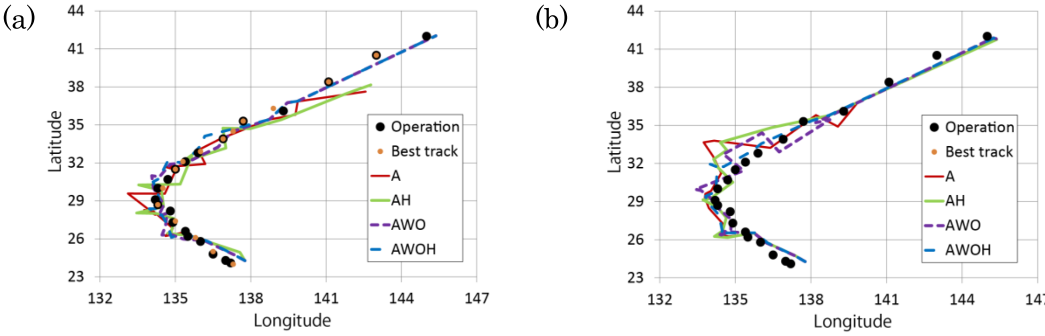

Figure 1 (a) Results of track simulations, the JMA operational and best tracks when the oceanic reanalysis data in 2013 was used. (b) Same as Fig. 1a except when the oceanic reanalysis data in 2011 were used.

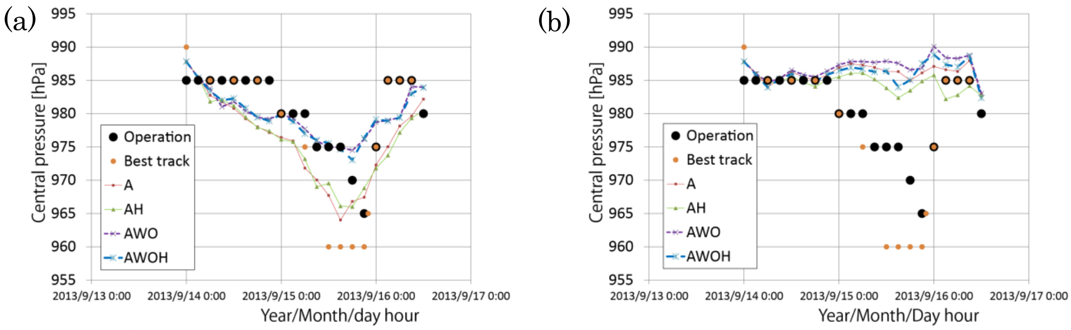

Figure 2 (a) Results of central pressure simulations, the JMA operational and best-track central pressures when the oceanic reanalysis data in 2013 was used. (b) Same as Fig. 1a except when the oceanic reanalysis data in 2011 were used.

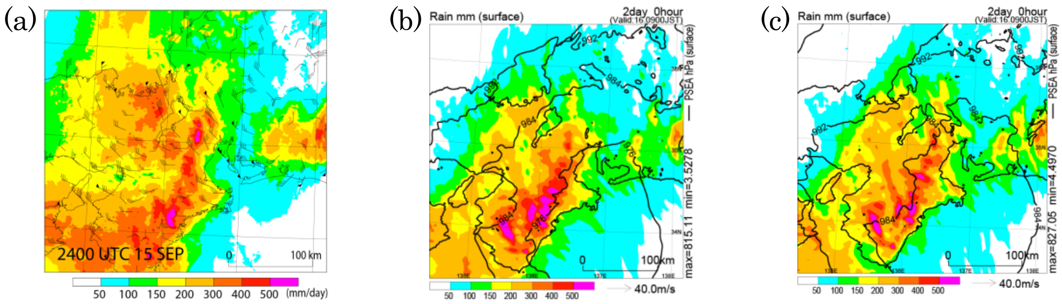

Figure 3 Horizontal distributions of total rains (mm per day) (a) by radar-amedas composite analysis, (b) in AH and (c) in AWOH accumulated from 0000 UTC 15 to 0000 UTC 16 September.

4. Concluding remarks

In addition to poorly simulations of total precipitation north of Kinki region, the simulations hardly simulated rapid intensification of Man-yi around 1200 UTC to 2100 UTC 15 September. Higher horizontal resolution of regional atmosphere and atmosphere-wave-ocean coupled models, more accurate atmospheric and oceanic initial conditions and improved physical processes such as cloud microphysics and boundary processes in the atmosphere and the ocean may be needed to improve the simulations.

Acknowledgement

This work was supported by MEXT KAKENHI Grant Number 25106708.

References

Usui, N., S. Ishizaki, Y. Fujii, H. Tsujino, T. Yasuda, and M. Kamachi (2006), Meteorological Research Institute multivariate ocean variational estimation (MOVE) system: Some early results. *Advances in Space Research*, **37**, 896-822.

Wada, A., N. Kohno and Y. Kawai (2010), Impact of wave-ocean interaction on Typhoon Hai-Tang in 2005, *SOLA*, **6A**, 13-16.