The effect of ocean coupling on torrential rains caused by Typhoon Man-yi in 2013

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1. Introduction

Typhoon Man-yi (2013) underwent a rapid lowering of sea-level pressure near the coast of Japan, south of Shikoku Island, before it made landfall. The rate of lowering of sea-level pressures exceeded 2.5 hPa h^{-1} (60 hPa d^{-1}) over the ocean north of 30°N from 0600 to 1200 UTC on 15 September. The typhoon made landfall on 16 September near Toyohashi-city, Aichi Prefecture in Central Japan and caused torrential rains in Kinki districts. It was the first time that the special warming regarding torrential rains was issued around the region. Wada (2015) reported that both preexisting high sea surface temperature conditions and storm-induced sea surface cooling affected the extraordinarily heavy rainfall particularly in the northern Kinki districts, which was simulated reasonably well in the numerical experiments. However, Wada (2015) did not mention the background of the effect of ocean coupling on the extraordinarily heavy rainfall.

The purpose of this study is to clarify the effect of ocean coupling on the torrential rains occurred in Kinki districts due to the passage of Man-yi by using the results of numerical simulations, which is the same as the results of Wada (2015).

2. Model and experimental design

Numerical simulations were conducted by both a regional nonhydrostatic model (NHM) and a regional atmosphere-wave-ocean coupled model (CPL) developed by Wada et al. (2010). CPL covered a ~2000 km x ~2400 km computational domain with a horizontal grid spacing of 2 km. Hereafter, 'A' indicates the results by NHM, whereas 'AWO' indicates the results by CPL. The year is expressed by four digits, 2013. Both NHM and CPL 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 0.1˚. The initial time was 0000 UTC on 14 September in 2013. The integration time was 60 hours. The model and experimental design are the same as Wada (2015).

3. Results and concluding remarks

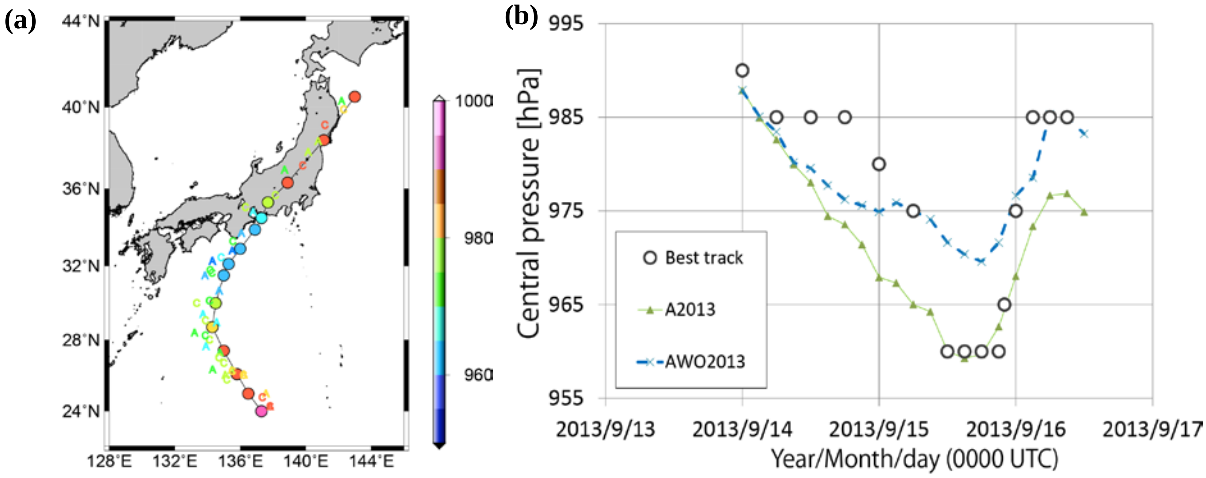

Figure 1 (a) Results of simulated tracks (A: NHM, C: CPL) and Regional Specialized Meteorological Center-Tokyo best track (b) Results of simulated central pressures and the best-track central pressure.

Figure 1 shows the results of simulated tracks (Fig. 1a) and central pressures (Fig. 1b). The coupling effect was negligible on the track simulation, whereas it was remarkable on the central pressure simulation. The A2013 experiment was able to simulate the minimum central pressure on 15 September reasonably well. However, the A2013 experiment indicated excessive intensification on 14 September. In that sense, the change in the simulated central pressure at the early integration time was improved in the AWO2013 experiment. An interesting issue in the simulations is the effect of the ocean coupling on the simulated precipitation.

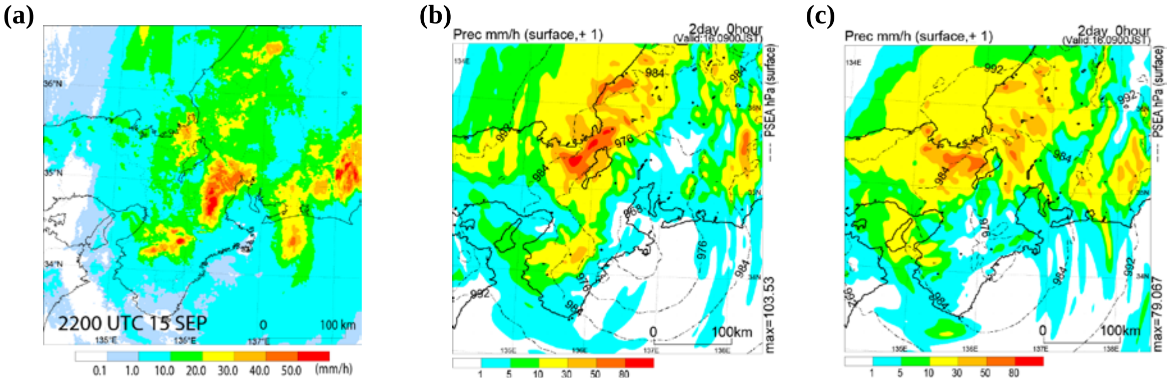

Figure 2 Horizontal distributions of accumulated hourly precipitation (a) by the Radar-Raingauge analyzed precipitation at 2200 UTC on 15 September, (b) in the A2013 experiment at 0000 UTC on 16 September and (c) in the AWO2013 experiment at 0000 UTC on 16 September. The unit is mm/hour.

Figure 2 displays the horizontal distribution of the Radar-Raingauge analyzed accumulated hourly precipitation and the results of numerical experiments. The corresponding time differed between the analysis and the results of numerical experiments because of the error of simulated track relative to the best track (Fig. 1a). Figure 2 reveals that the distribution of precipitation was asymmetric, indicating that the storm underwent axisymmetric-to-asymmetric transition. In particular, the precipitation was remarkable on the downshear left side of the northeastward moving direction of the typhoon (Wada, 2015). The feature was simulated reasonably well in both A2013 and AWO2013 experiments. However, the amount of the precipitation significantly reduced due to the ocean coupling.

Figure 3 shows the horizontal distribution of specific humidity at a height of 404 m in the atmospheric boundary layer at 0000 UTC on 16 September. The reduction of precipitation shown in Fig. 2 is consistent with the reduction of specific humidity in the boundary layer. Figure 3 indicates that specific humidity was relatively high around the storm center and on the right side of the moving direction. Around the Wakasa-Wan in the Sea of Japan, the linearly-aligned pattern apart from high specific humidity area on the right side of the moving direction was remarkable in both A2013 and AWO2013 experiments. The linearly-aligned pattern is closely related to extremely torrential rains in the northern Kinki districts (Fig. 1b-c). The results suggests that the ocean coupling did affect not only the rainfall around the storm center but also extremely torrential rains and the associated moisture distribution on the downshear-left side of the moving storm.

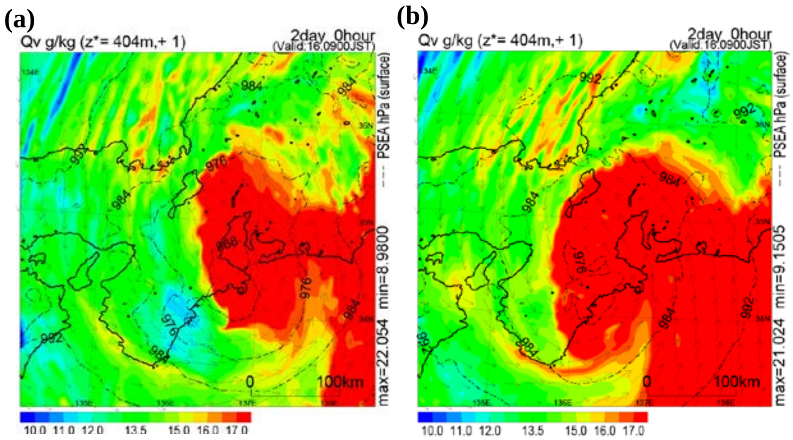

Figure 3 Horizontal distributions of specific humidity (g/kg) at a 404-m height at 0000 UTC on 16 September.

Acknowledgement

This work was supported by MEXT KAKENHI Grant Number 25106708

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