Extremely deepening of central pressures for Typhoon Neoguri in 2014 simulated by an atmosphere-wave-ocean coupled model and its dependency on the horizontal resolution.

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1. Introduction

During 2014 typhoon season, Typhoon Neoguri made landfall over Kyushu late on 9 July. The typhoon was large and powerful with a minimum sea-level pressure of 930 hPa from 1800 UTC 6 to 0000 UTC 7 July according to the Regional Specialized Meteorological Center (RSMC) Tokyo best track data. However, the Japan Meteorological Agency (JMA) deterministic Atmospheric Global Spectral Model with a horizontal resolution of approximately 20 km (AGSM20) predicted a more extreme deepening of central pressures (Fig. 1).

The evolution of mean central pressure predicted by AGSM20 indicates that AGSM predicted central pressures were higher than the RSMC best-track central pressures until 0600 UTC on 7 July. Mean forecasts agreed with the best track central pressures better than the prediction. However, both AGSM20 predictions and JMA forecasts showed excess deepening of predicted central pressures after 0600 UTC on 7 July. For example, the time series of central pressures predicted by AGSM20 from the initial time at 1200 UTC on 4 July reveals that the minimum central pressure was 905 hPa, 25 hPa deeper than the best track minimum central pressure. In addition, the peak of minimum central pressure shifted one day afterward even though AGSM could not predict rapid intensification from 4 to 5 July.

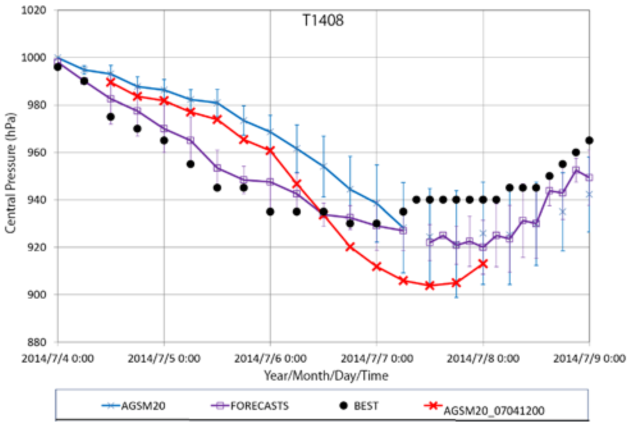

Figure 1 Time series of best-track central pressure (BEST), predicted mean central pressure by JMA global spectral model (AGSM20) and mean central pressure forecasts (FORECASTS) issued by JMA with the standard deviation during the typhoon every 6 hours , and that of central pressure predicted by AGSM20 from the initial time at 1200 UTC on 4 July (AGSM20_07041200).

2. Model and experimental design

It is known that typhoon-induced sea surface cooling helps suppress such kinds of excess intensification. Therefore, the purpose of this report is to verify the effect of typhoon-induced sea surface cooling on intensity predictions for Neoguri by using an atmosphere-wave-ocean coupled model with a horizontal resolution of 2 km. To examine the sensitivity of the horizontal resolution on the intensity predictions, sensitivity experiments were also performed with horizontal resolutions of 5 km and 10 km. The computational domain covers approximately 2400 km x 2800 km.

Numerical simulations were performed by a nonhydrostatic atmosphere model and a coupled atmosphere-wave-ocean model (Wada et al. 2010). The coupled model (CPL) has been developed based on the Japan Meteorological Agency nonhydrostatic atmosphere model (NHM). The horizontal resolution is shown in Table 1. Both CPL and NHM had 55 vertical levels with variable intervals from 40 m for the near-surface layer to 1013 m for the uppermost layer with the top height approaching nearly 26 km. The integration time was 84 hours (84 h) with a time step of 4 seconds. The initial time was 0000 UTC on 4 July in 2014.

Table 1 List of numerical experiments: acronym, model and horizontal resolution.

Acronym	Model	Horizontal resolution
A2km	NHM	2 km
A5km	NHM	5 km
A10km	NHM	10 km
AWO2km	CPL	2 km
AWO5km	CPL	5 km
AWO10km	CPL	10 km

The JMA global objective analysis data with a horizontal resolution of approximately 20 km was used for atmospheric initial and lateral boundary conditions. The latter was provided during the integration every 6 hours. The oceanic initial conditions except the sea surface temperature were obtained from the oceanic reanalysis datasets with a horizontal resolution of 0.5º calculated by the Meteorological Research Institute multivariate ocean variational estimation (MOVE) system (Usui, et al. 2006). Microwave optimally interpolated sea surface temperature product with a horizontal grid spacing of 0.25° (http://www.remss.com/measurements/sea-surface-temperature/) was used as an initial condition for the sea surface temperature. In this study, no cumulus parameterization was used in conjunction with three-ice bulk cloud microphysics.

3. Results and concluding remarks

The simulated tracks showed marked northward biases from 126˚E to 132˚E during the middle of integration time. The typhoon positions predicted by AGSM20 and forecast positions became scattered around the Ryukyu chain, whereas simulated tracks became close to the RSMC best track positions (Fig. 2a). The impact of horizontal resolution on the track simulations is negligible during the early integration (Fig. 2b). However, the moving speed of storms in the experiments A5km and AWO10km tended to be relatively fast compared to that in the experiments A2km, AWO2km and that in the best track analysis. This is probably due to the setting of the parameter associated with lateral boundary condition.

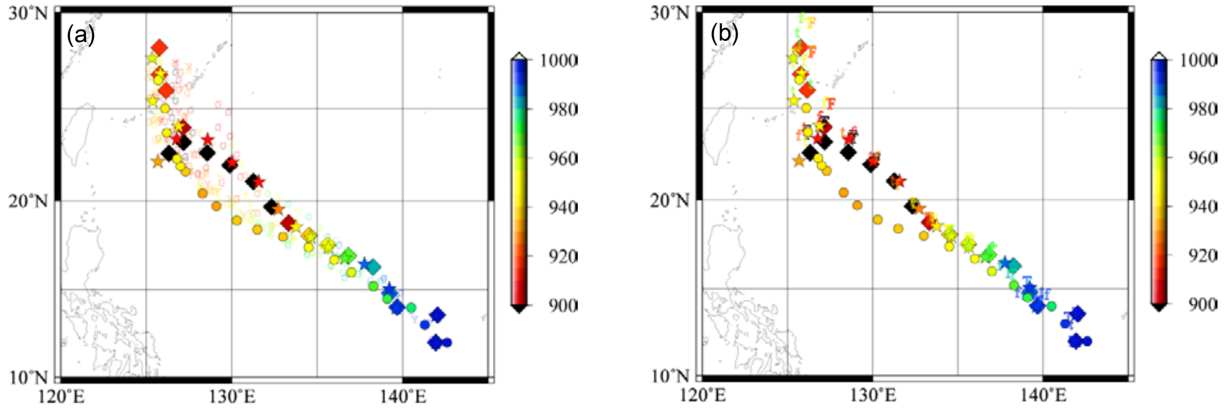

Figure 2 (a) Results of numerical simulations (◆:A2km, ★:AWO2km) with RSMC best-track data (●). The characters 'G' indicates predictions by AGSM20, while 'Y' indicates forecasts. (b) Same as (a) except for 'F' (A5km), 'T(A10km), 'f' (AWO5km) and 't' (AWO10km) without 'G' and 'Y'

Kanada and Wada (2015) reported that the appropriate horizontal resolution (~2 km) should be used to examine extremely intense TCs with extremely intensifying rates. In other words, it is expected that excess intensification could be suppressed by relatively coarse horizontal resolution. Figure 3 shows the time series of central pressures simulated in six experiments included in the difference of horizontal resolution and the difference between NHM and CPL. Even in the horizontal distribution of 10 km, however, the central pressure excessively deepened compared to the best track analysis even though CPL was used. The difference of central pressure simulations was relatively small compared with that between the horizontal resolutions of 5 km and 10 km, reported in Kanada and Wada (2015).

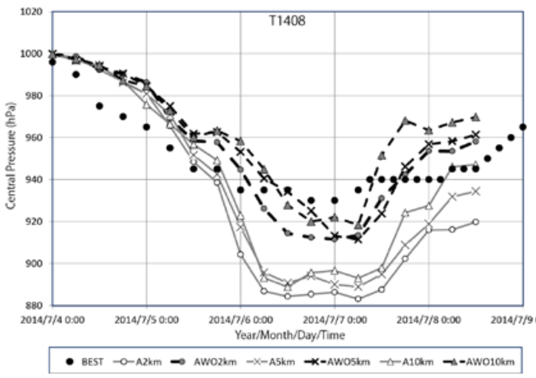

Figure 3 Time series of simulated central pressures in the experiments shown in Table 1.

Therefore, excessive intensification in the simulation of a typhoon is not completely suppressed by coarse horizontal resolution and typhoon-induced sea surface cooling simulated by an atmosphere-ocean coupled model. This is a lesson learnt by this study. In terms of the accuracy of central pressure, the accuracy of the best track central pressure has been a serious issue since there is less in situ observation in the vicinity of the center of typhoons in the western North Pacific than in the North Atlantic. Another issue is on the quality of global objective analysis data frequently updated depending on the upgrade of the system. Atmospheric initial and environmental conditions may affect simulated central pressures. These will be subjects in the future.

Acknowledgement

This work was supported by MEXT KAKENHI Grant Number 15K05292.

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