The impact of oceanic observations on tropical cyclone intensity prediction in the case of Typhoon Namtheun (2004)

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1. Introduction

Local sea surface cooling (SSC) caused by a passage of a tropical cyclone (TC) plays a significant role in TC intensity predictions by using atmosphere-ocean coupled models. However, whether or not environmental oceanic conditions affect TC intensity predictions has not been clear. The quality of environmental oceanic reanalyzed dataset depends on the frequency of observations. The frequency of observations has been still insufficient even though nearly three-thousand ARGO floats have been deployed in the world ocean. Here we show the impact of oceanic observations such as in situ observations by voluntary ships, research vessels, buoys and floats, and satellite altimeters on the TC intensity prediction in the case of Typhoon Namtheun (2004).

2. Methods

The outline of numerical predictions in the case of Typhoon Namtheun (2004) has been already reported in Wada and Murata (2007). The computational domains consist of two regional nests: an outer nest with a grid spacing of 6 km and inner nest with a grid spacing of 2 km. In the outer-nest domain, a cumulus parameterization was conjunctively used with a cloud microphysics. After 30-hour integration in the outer-nest domain, a calculation in the inner-nest domain was initiated to be started without using a cumulus parameterization. The atmosphere-ocean coupled model used in the present study was modified in the following manners: The entrainment formulation of Deardorff (1983) was updated from Wada and Murata (2007) and sea surface boundary process was also modified as the magnitude of diurnal sea surface temperature (SST) variations could be realistically reproduced compared with observations.

Using the North Pacific version of Meteorological Research Institute multivariate ocean variational estimation system, three types of oceanic reanalysis dataset were prepared for TC intensity predictions by the coupled model:

a. no assimilation of both in situ observations and sea surface height observations by satellite altimeters
b. no assimilation of in situ observations and assimilation of sea surface height observations by satellite altimeters
c. assimilation of both in situ observations and sea surface height observations by satellite altimeters

Figure 1 depicts the locations of in situ observations on July 2004. The number of in situ observations was not always sufficient in the computational domain (Fig.2a), while sea surface height data by satellite altimeters (JASON1 and ENVISAT) covered in the computational domain (Fig. 2b).

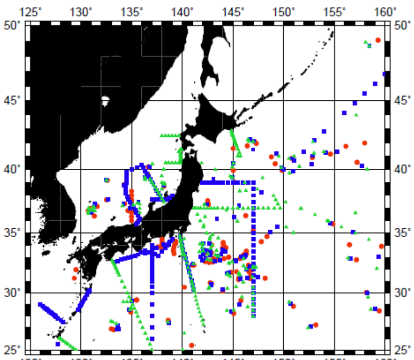

Fig. 1 Locations of in situ observations on July 2004. Red circles show the locations on the early July, blue squares show the locations on the middle July, and green triangles show the locations on the late July.

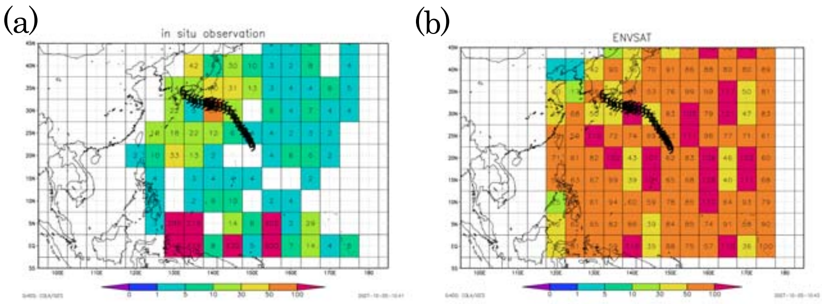

Fig.2 The horizontal distribution of the number of (a) in situ oceanic observations and (b) sea surface height observations by satellite altimeters on the late July with a grid spacing of 5°. Typhoon Marks shows the track of Typhoon Namutheun (2004).

3. Results

3-1 Environmental oceanic conditions

Figure 3 shows the horizontal distribution of SSTs on 29 July 2004 and predicted TC positions depicted every six hours during the 40-hour integrations. A cold eddy off Kii peninsula, the area over 29℃ and local SSC around 33° N,140° E were calculated in three SST fields, respectively. However, there was no significant difference among the track predictions. This indicates that environmental oceanic conditions hardly affect the TC track prediction.

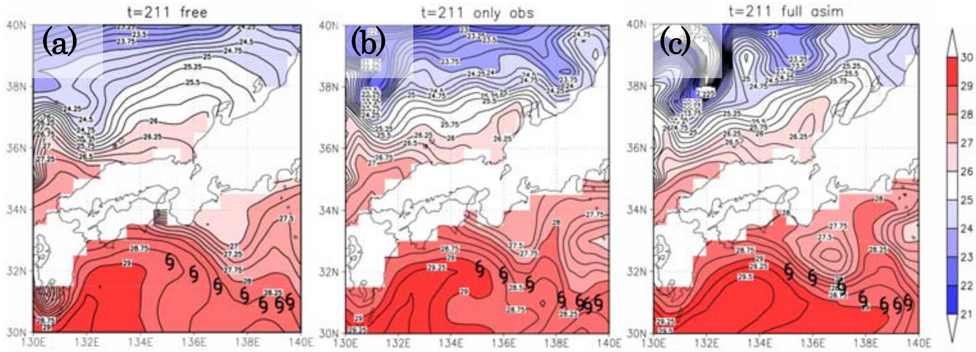

Fig. 3 Horizontal distribution of SST (Shades and contours) on 29 July 2004 and predicted TC positions (typhoon marks) every six hours during the 40-hour integration. (a) Case a, (b) Case b, and (c) Case c.

3-2 Tropical cyclone predictions

Figure 4 shows the results of TC track and intensity predictions by using the atmosphere-ocean coupled model. During the early integrations, minimum central pressure in Case c was the lowest of three numerical predictions probably due to eastward extension of SST higher than 29℃. However, the results of TC intensity prediction were almost all the same at 27-hour integration again. After that, minimum central pressure in Case b was the lowest.

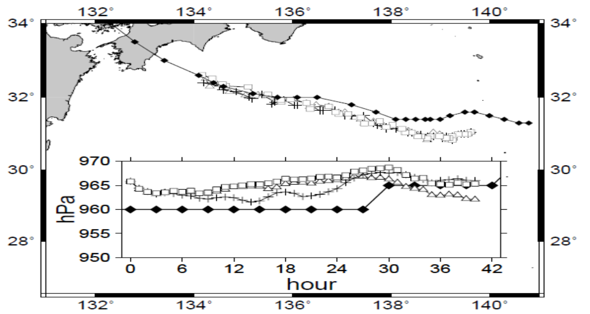

Fig. 4 Predicted tropical cyclone positions and time series of minimum central pressure. Circles show the result of Case a. Triangles show the result of Case b. Crosses show the result of case c.

Figure 5 shows the results of TC intensity prediction by using the non-coupled (atmosphere-only) model. Minimum central pressure in Case c continued to be the lowest of three numerical experiments during the integration, which was clearly different from the results shown in Fig. 4. The difference in minimum central pressure among the three environmental oceanic conditions was at most 5 hPa at 15-hour integration (Fig. 4), while the difference of minimum central pressure between coupled (Fig. 4) and non-coupled (Fig. 5) simulations were nearly 15 hPa.

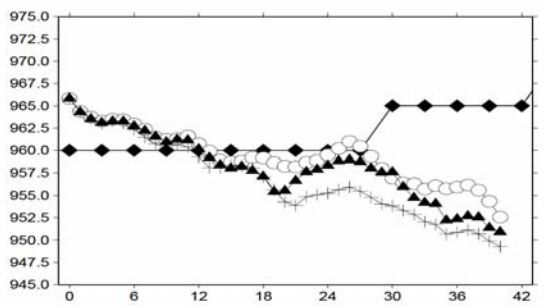

Fig. 5 Time series of minimum central pressure predicted by non-coupled model. Circles show the result of Case a. Triangles show the result of Case b. Crosses show the result of case c.

4. Concluding remark

The result of relatively small impact of environmental oceanic condition on TC intensity predictions suggests that environmental oceanic conditions play a minor role in TC intensity predictions compared with the role of local SSC. However, we should note that uncertainty of environmental oceanic condition possibly inhibits the improvement of tropical cyclone intensity predictions by atmosphere-ocean coupled models. The uncertainty of environmental oceanic condition may increase where in situ observations are scarce (Fig. 3a). We need to further investigate the impact of oceanic observations of TC intensity predictions for many TCs.

References

Deardorff、J. W. (1983): A multi-limit mixed-layer entrainment formulation. J. Phys. Oceanogr., 13, 988-1002.

Wada and Murata (2007): Effect of horizontal resolution and sea surface cooling on simulations of tropical cyclones in case of Typhoon Namtheun (2004) by a coupled MRI tropical cyclone-ocean model. WMO CAS/JSC WGNE Report. 9-09.