Typhoon-ocean interaction in Typhoon Megi (T0415) using an atmosphere-mixed-layer ocean coupled model

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1. Introduction

In general, typhoon-ocean interaction is recognized as suppressing the intensification of typhoons by local sea surface cooling (SSC). However, the interaction does not always occur in numerical experiments. One of the examples is the case of early developing stage of which sea surface temperature (SST) is over 28℃ (Wada, 2005a). In this case, moving speed of the typhoon tends to be faster. The fast translation is also seen in typhoons passed by in mid-latitudes where SST is under 28℃. In the present report, we focus on Typhoon Megi (T0415) passed by in the Japan Sea located in mid-latitudes.

2. Numerical experiments

The numerical model using in this study is the non-hydrostatic atmosphere-ocean coupled model (Wada, 2005b). The horizontal resolution is 6km with 252x252 grids with 40 vertical layers. The initial time of numerical integration is at 00UTC on August 19 in 2004. The integration time is 48 hours. The initial and lateral conditions are obtained by interpolation every 6 hours from Meso-Scale Model (MSM) analysis data with 40 vertical layers, which is the same as that of the forecast model. The oceanic initial condition is obtained from reanalysis data by the MRI Ocean Variational Estimation (MOVE) system. Note that T0415 is outside of the computed domain in the initial field.

Results of track prediction and predicted moving speed every 1 hour are shown in Fig. 1. The predicted track is almost the same as the track of Japan Meteorological Agency (JMA) best track during 24-hour in the early integration. The moving speed is nearly 10-15m/s, which is generally faster than that in developing and mature stages. Minimum central pressure (MCP) of the typhoon at T+10h is 980hPa, which is weaker than that of JMA best track MCP of 970hPa. However, the tendency of computed MCP, which shows decaying, agrees well with that of JMA best track during 24-hour in the early integration. This suggests that T0415 is successfully simulated if the integration time is confined within 24 hours.

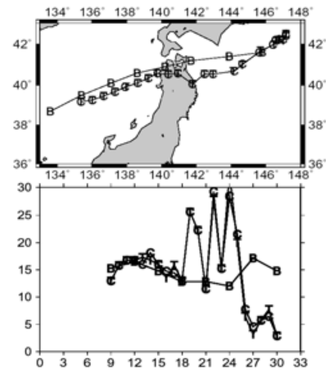

Figure 1 (Upperpanel) Results of track prediction of T0415 every 1 hour in the non-coupled (N), coupled (C), and JMA best track every 3 hours (B). (Lower panel) moving speed of T0415.

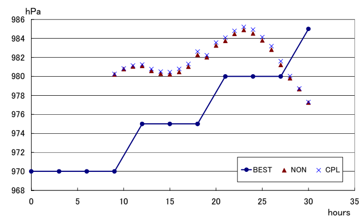

Figure 2 Minimum central pressure of T0415 in the non-coupled, coupled, and JMA best track.

3. Results

<u>3-1 Sea surface temperature and potential temperature at the lowest level</u>

The difference of SST between the non-coupled and coupled experiments remarkably appears in the Japan Sea, which maximum SSC is over 1℃ at T+18h. The maximum SSC is found on the leftward of moving direction, which is opposite of the typical SSC during the passage of typhoons. The difference also appears in potential temperature (PT) at the atmospheric lowest layer of 20m height. At the level, cyclonic but asymmetric circulation where the maximum wind is found around south of the typhoon center is evident. The difference of MCP between non-coupled and coupled experiments does not appear (Fig. 2) in spite of appearance of SSC.

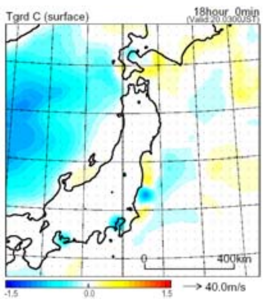

Figure.3 Difference of SST in between coupled and non-coupled experiments.

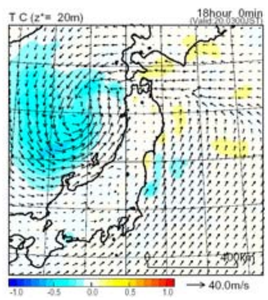

Figure 4 same as Fig. 3 except for potential temperature with surface wind at the lowest level (20m height).

<u>3-2 Surface flux</u>

The ocean coupling effect is evidently found in latent heat flux and accumulated precipitation (Wada, 2006). The effect appears notably within a radius of 100km from the typhoon center. (Zhu et al., 2004; Wada, 2006).

The surface fluxes of mixing ratio of water vapor (Qv) in both non-coupled and coupled experiments are shown in Figs. 5. Around the center of the typhoon, the surface flux of Qv is low. The maximum surface flux is found on the leftward of moving direction (Fig. 5(a)). At the region, the decrease of surface flux is salient (Fig. 5(b)) because the region corresponds to the maximum SSC region.

The difference of Qv and wind velocity in between non-coupled and coupled experiments is shown in Figs. 6. The maximum negative difference of Qv is found south of the typhoon center where the maximum wind velocity is found (Fig. 4), while the negative difference of wind velocity is salient on the leftward (higher latitudes) of moving direction. The difference of Qv appeared overall the Japan Sea agrees well with that of SSC by T0415. However, wind velocity at the surface of 20m height does not correspond to the SSC response to PT and Qv. This suggests that surface wind velocity with cyclonic but asymmetric circulation is influenced by diabatic heating not only around the typhoon center but also in higher latitudes. The process may be related to transformation from a tropical cyclone to a extratropical cyclone.

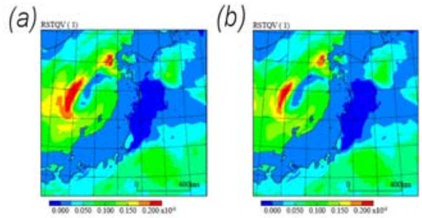

Figure 5 Surface flux of Qv (a) in non-coupled experiment, (b) in coupled experiment.

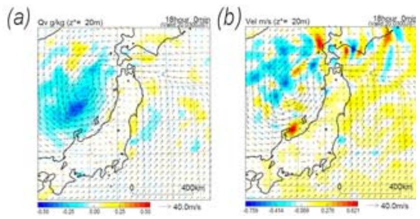

Figure 6 (a) Difference of Qv at the height of 20m in between coupled and non-coupled experiments, (b) same as (a) except for wind velocity at the height of 20m.

<u>3-3 Precipitation</u>

The difference of mixing ratio of rain water (Qr) in between non-coupled and coupled experiments is shown in Fig. 7(a). The pattern of the difference does not correspond to that of PT and Qv. The deviation is notable in higher mid-latitudes (north of 40N). The difference of accumulated precipitation shown in Fig. 7(b) has a similar pattern to that of Qr, which is different from the differences typically seen by typhoon-ocean interaction.

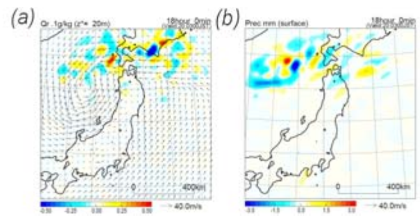

Figure 7 (a) Difference of Qr at the height of 20m in between coupled and non-coupled experiments, (b) same as (a) except for accumulated precipitation during 18 hours.

4. Related weather event to T0415

During the passage of T0415, air temperature at the surface suddenly rose in Shounai region from 00UTC to 03UTC on August 20. The sudden rising of air temperature during the period is comparable to the temperature by radar-AMeDAS composite analysis. The difference of simulated air temperature in between non-coupled and coupled experiments is negligibly small. This suggests that the sudden rising of air temperature is irrelevant to typhoon-ocean interaction. At Turuoka observing station, simulated air temperature tends to be overestimation. This is partly because of failure of simulating precipitation in Shounai region and positive bias of initial air temperature.

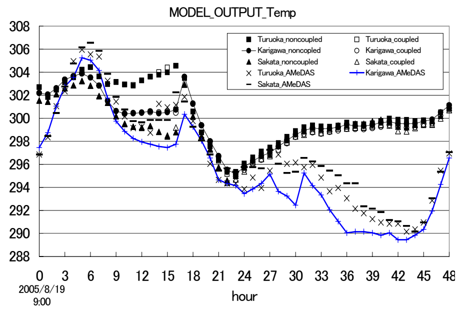

Figure 8 Simulated and observed air temperature at the surface at three observing station (Sakata, Karigawa, and Turuoka) in Shounai region.

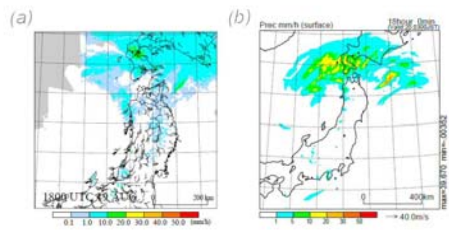

Figure 9 (a) Distribution of 1-hour precipitation and winds at the surface by radar-AMeDAS composite analysis at 18UTC on August 19, (b) distribution of simulated 1-hour precipitation at T+18h.

<u>References</u>

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