IMPLEMENTATION OF THE JMA TYPHOON MODEL COUPLED WITH THE MRI MIXED LAYER OCEAN MODEL AND ITS APPLICATION FOR TYPHOON BILIS

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1. Introduction

We, JMA (Japan Meteorological Agency)/MRI(Meteorological Research Institute) are developing a numerical weather prediction model coupled with a mixed layer ocean model (typhoon-ocean coupled model) in order to improve mainly forecasts of the intensity of tropical cyclones (TCs). The JMA typhoon Model (TYM) updated on March 2001 is an operational regional model with an initialization technique for TC (typhoon bogusing). The MRI mixed layer ocean model is designed according to appendix of Bender et al.(1993) and is developed by Wada (2002). The typhoon-ocean coupled model is based on the combination of these two models. Here, the impact on which the spatial distribution of SST and the SST variation affect the prediction of intensities of Typhoon Bilis is investigated.

2. Procedure of the typhoon-ocean coupled model, and initial and boundary conditions

The exchange process between the atmosphere and the ocean in the typhoon-ocean coupled model is explained. Some physical elements are exchanged between the atmosphere and the ocean whenever the ocean model runs one time step because the ocean model generally adopts a longer time step than that of the TYM. The physical elements of the TYM handed over to the ocean model are wind stresses, sensible and latent heat fluxes, and the information of topography used in the TYM. The effect of long-wave radiative heat flux and solar insolation is neglected in this typhoon-ocean coupled model. The direction of wind stresses can be modified when the TYM adopts Lambert coordinate system. As for the exchange methodology at the atmosphere-ocean interface, all elements handed over to the ocean model are all linearly interpolated to the coordinate system of the ocean model. The horizontal grid resolution of the TYM is 24km around the typhoon center and 1/5 degrees of the ocean model. The ocean model can be executed in one step after these procedures. The model-computed SST is then given to the TYM after the linear interpolation like the exchange from the atmosphere to the ocean. With regard to the ocean initial conditions of sea temperatures and salinities, Levitus climatological data are given, however initial SSTs are derived from the TYM at the initial time. The atmospheric initial conditions are usually determined from the objective analysis system in JMA Global spectral model (GSM). However, the atmospheric initial conditions are obtained from the predictions of the GSM at T+00h in this experiment. The atmospheric boundary conditions determined by GSM are applied every 3 hours.

3. Impact on which SST cooling affects the intensities of Typhoon Bilis

First, we conducted two numerical experiments using the TYM with two SST data, the climate SST and the daily SST, in order to investigate the prediction difference of the intensities of TCs in the different spatial distribution of SST. We took the case of Typhoon Bilis on August 20, 2000 for example, which the initial time of this simulation was at 1200 UTC 20 August 2000. Both experiments indicated the developing of Typhoon Bilis. The central pressure of Typhoon Bilis was 933.3hPa in the climate SST and 920hPa in the daily SST after T+39h (Figure 1). The difference of 13.3hPa was largely because the daily SST was 1 degree greater than the climate SST along the typhoon translation.

Next, we compared the TYM with the typhoon-ocean coupled model using the daily SST. The central pressure of Typhoon Bilis was 925.2hPa after T+39h (Figure 1) in the typhoon-ocean coupled model. The difference of the intensity of Typhoon Bilis between the TYM and the typhoon-ocean coupled model was 5.2hPa and less than the difference in between the climate SST and the daily SST. According to the result of the typhoon-ocean coupled model, Maximum SST cooling was about 1.4 ℃ (Figure 2) that was smaller than the SST by TRMM/TMI (Figure 3).

As noted the atmospheric responses, the effect of the negative feedback can be seen from the result of the typhoon-ocean coupled model. A maximum wind speed in the typhoon-ocean coupled model was weaker than that in the TYM. Besides, sensible and latent heat fluxes decreased mainly around the typhoon center. Moreover, the amount of precipitation near the center of Typhoon Bilis decreased compared with that in the TYM at the same area. These results in the typhoon-ocean coupled model did not contradict the result of Bender et al. (1993).

4. Discussion

We constructed the typhoon-ocean coupled model system composed of the TYM and the MRI mixed layer ocean model. This model realized SST cooling by passage of Typhoon Bilis in the ocean, and the negative feedback in the atmosphere. However, we will need further improvements, particularly the physical processes, of both models. One of the important physical processes that we should improve is the boundary layer physics in the TYM. Bender et al. (2001) reported that the low level wind in the GFDL Hurricane-ocean coupled model has exhibited a large negative bias and poor pressure wind-relationship, as the model tends to under-predict surface wind speeds for a given central pressure compared with data of GPS sondes. This is due to the lower version of closure schemes of Mellor-Yamada's. Bender et al. (2001) reported that a level 2.5 Mellor-Yamada turbulent closure scheme was a good performance for pressure-wind relationship, although the JMA actually adopt a level 2 Mellor-Yamada turbulent closure scheme. Moreover, it is evident that the reduction to 10m by the Monin-Obukhov formulation is not valid (Bender et al., 2001). It is the reason the TYM-ocean coupled model adopts the lowest level layer as the surface winds.

The other problem is the interface process between the atmosphere and the ocean. The MRI mixed layer ocean model only adopts the sensible and latent heat fluxes (Bender et al., 1993), and solar insolation and long-wave radiative fluxes are neglected. We try to improve the process of sea surface heat fluxes using diurnal cycling algorithm.

References

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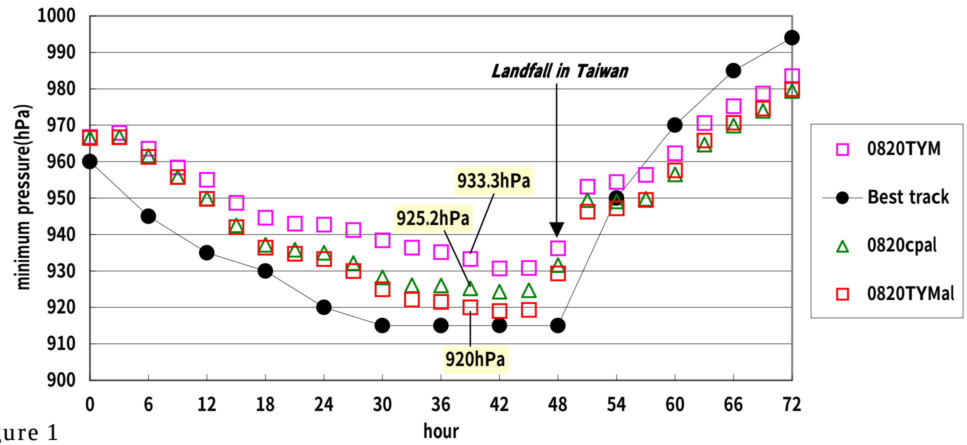

Figure 1
Time series about the intensity forecast of Typhoon Bilis. Horizontal axis represents hours and vertical axis indicates the minimum pressure of Typhoon Bilis.

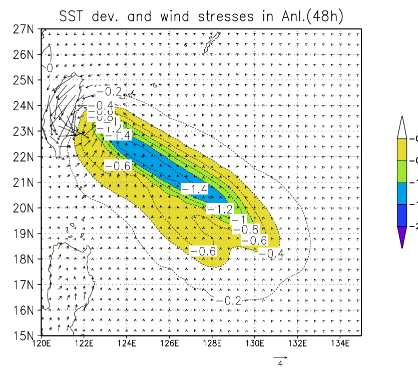

Figure 2
Horizontal SST deviations from the initial time(T+0h) to T+48h. Contour lines and shades show the SST deviation. Vectors show the distribution of wind stresses

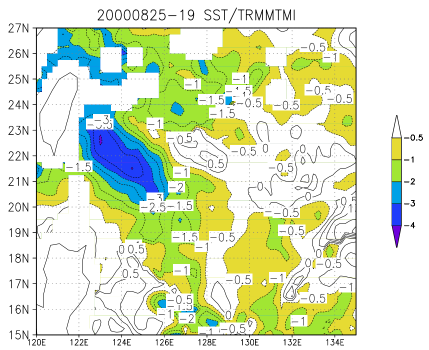

Figure 3
Horizontal SST deviations from August 19, 1998 to August 25, 1998. 'TMISST (Ver. 2.0)' was produced and supplied by the Earth Observation Research Center, National Space Development Agency of Japan."