

Introduction of an atmosphere-wave-ocean coupled model into the NHM-LETKF

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1. Introduction

Data assimilation system by using the local ensemble transform Kalman filter (LETKF) has been used for studies on the atmospheres and the oceans more frequently than before. LETKF was incorporated into the Weather Research and Forecasting (WRF) model (WRF-LETKF) (Kunii and Miyoshi, 2012) and the Nonhydrostatic atmosphere model (NHM) developed by the Japan Meteorological Agency (JMA) and Meteorological Research Institute of the JMA (NHM-LETKF) (Kunii, 2014). A recent study suggested that variations in sea surface temperature led to the improvement of track predictions of Typhoon Sinlaku in 2008 (Kunii and Miyoshi, 2012). However, the variation in sea surface temperature was simply provided as ensemble perturbations, arbitrarily determined without any considerations of oceanic physical processes including effects of air-sea interactions, turbulent mixing and upwelling on the variation in sea surface temperature.

The final goal of this study is to construct the air-sea coupled assimilation system using an atmosphere-wave-ocean coupled model and LETKF. This is the preliminary report that documents the installation of the air-sea coupled model to NHM-LETKF. It should be noted that this study only describes the replacement of only the prediction part from NHM to the atmosphere-wave-ocean coupled model. This study is expected to show the effects of the air-sea coupled system on atmospheric analyses.

2. Assimilation system and experimental design

The NHM-LETKF used in this study is based on Kunii (2014). The system has been developed based on the WRF-LETKF system. However, the two systems quite differs each other.

Figure 1 displays a schematic diagram of the NHM-LETKF developed in this study. The original NHM-LETKF system uses merged satellite and in-situ data global daily sea surface temperature (MGDSST). However, this study also uses daily oceanic reanalysis data calculated by the Meteorological Research Institute multivariate ocean variational estimation (MOVE) system (Usui et al., 2006). Both MDGSSST and MOVE data are updated at a daily interval and are used as the oceanic initial condition of the atmosphere-wave-ocean coupled model.

The coupled atmosphere-wave ocean model consists of the NHM, the third generation ocean wave model, and a multilayer ocean model (Wada et al., 2010). It should be noted that sea surface temperature calculated by the coupled model in the prediction part is not used in the subsequent analysis part. The analysis part in the LETKF is not changed from Kunii (2014). This will be a future subject in the future. The ocean state (wave conditions) is assumed to be motionless at the initial time.

This study addresses Typhoon Sinlaku in 2008. The analysis and prediction covered a ~3600 km x ~1900 km computational domain with a horizontal grid spacing of 15 km. The system had 40 vertical levels with variable intervals from 40 m for the near-surface layer to 1180 m for the uppermost layer. The system had maximum height approaching ~23 km. The analysis period is from 1200 UTC 1 to 1800 UTC 19 September in 2008. The number of

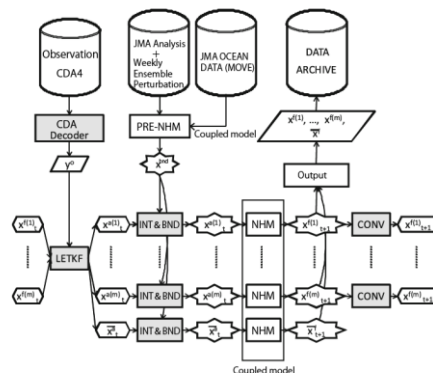


Figure 1 Schematic diagram of NHM-LETKF coupled with the atmosphere-wave-ocean model in the prediction part.

ensemble member is 20.

3. Results

Figure 2 shows three results of analyzed positions of Typhoon Sinlaku together with the Regional Specialized Meteorological Center Tokyo best track (hereafter the JMA best track). The result indicated that a difference in sea surface temperature between MGDSST (CNTL in Fig. 2) and MOVE did directly affect the analysis of the central position of Sinlaku in particular at an early developing phase (south of 20°N) and a decaying phase (north of 30°N). In addition, there is a clear difference in analyzed central positions between the NHM (MOVE in Fig. 2) the coupled model (MOVECP in Fig. 2) only at an early developing phase (south of 20°N). This result suggests that both the difference in sea surface temperature field and ocean coupling certainly affect the analysis of typhoon position.

Figure 3 exhibited evolutions of analyzed central pressures together with the JMA best-track central pressure. All the three falling rates of analyzed central pressure are moderate compare with the JMA best track one during the intensification phase from 9 to 13 September due to the relatively coarse resolution (~15 km) of the current developing system. However, there is a clear difference in falling rates among the three analyses during the phase. Typhoon – induced sea surface cooling helps suppression of intensification. On the contrary, there is less difference in analyzed central pressures among the three since 14 September when the typhoon underwent the mature or decaying phase.

4. Concluding remarks

Reduction in the falling rate of the analyzed central pressure in MOVECP is a reasonable result in that sea surface cooling induced by a typhoon is calculated by the coupled model and the cooling does affect the intensification of the typhoon as a suppression of the intensification particularly during the intensification phase. If the resolution of the analysis system were finer, the analyses of the central pressure would be improved.

Acknowledgement

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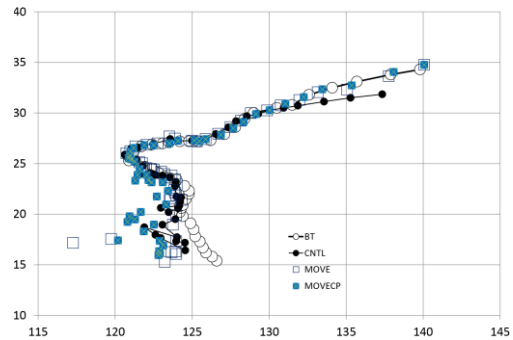


Figure 2 Results of analyzed center positions of Typhoon Sinlaku in CNTL (MGDSST is used), MOVE (Noncoupled system) and MOVECP (Coupled system) together with the JMA best track.

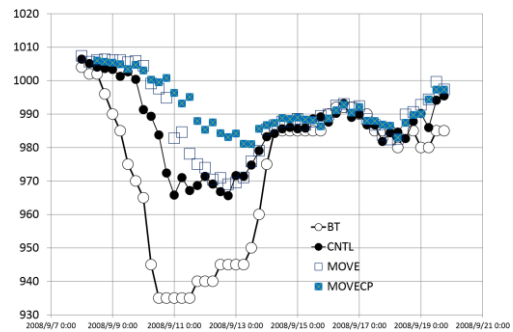


Figure 3 Evolutions of analyzed central pressures of Typhoon Sinlaku in CNTL (MGDSST is used), MOVE (Noncoupled system) and MOVECP (Coupled system) together with the JMA best track central pressure.