Numerical Investigations on Intensification of Typhoons, Sea Surface Cooling and Oceanic Environments in the Western North Pacific

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Motivation

1) Rapid intensification of Typhoon Man-yi (2013) occurred south of Sikoku island (corresponding to the Kuroshio region) and the relation to oceanic environments are one of interesting topics to understand the interactions between typhoons and the ocean.
2) In order to understand the interactions, numerical simulations of Man-yi by atmosphere-wave-ocean coupled model is effective.
3) However, uncertainties remain in atmospheric and oceanic initial conditions for numerical simulations for typhoons.
4) In order to reduce the uncertainties, we have developed an atmosphere-ocean coupled data assimilation system based on a local ensemble transform Kalman filter(LETKF).
5) In future, the LETKF-based atmosphere-ocean coupled data assimilation system will contribute to understanding rapid intensification processes such as Man-yi.

Contents

This poster consists of the following two parts:

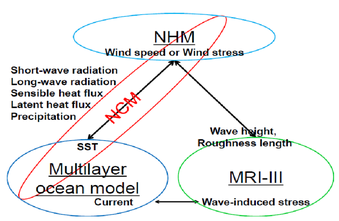
1) Numerical simulations on rapid intensification of Typhoon Man-yi (2013) by using an atmosphere-wave-ocean coupled model (Wada et al., 2010) with different oceanic initial conditions.
2) The development of the LETKF-based atmosphere-ocean coupled data assimilation system based on the atmosphere-wave-ocean coupled model (Wada et al., 2010). We show results of preliminary analyses in the case of Typhoon Sinlaku in 2008.

Model (an atmosphere-wave-ocean coupled model)

Atmosphere: NHM (Saito, 2012). Operational model in JMA

Ocean: Multilayer model (Three layers and four levels)

Wave: MRI-III: Third generation model.



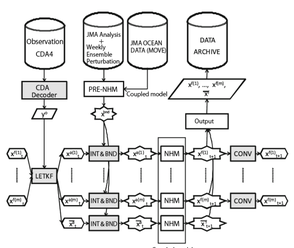
NHM-LETKF System

NHM-LETKF: Kunii (2014)

Forecast model: NHM (uncoupled) or the coupled model (coupled)

SST: MGDSST (0.25˚,uncoupled CNTL) or

MOVE (0.1˚ or 0.5˚, coupled or uncoupled, simulation or assimilation)



Typhoon Man-YI (T1318)

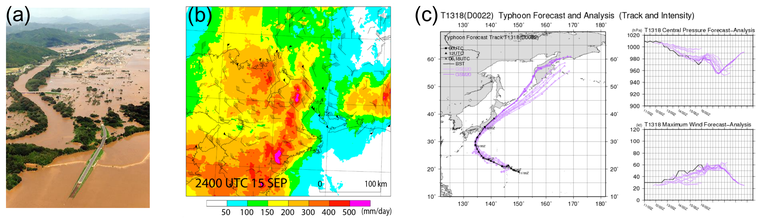


Figure 1 (a) Photo, (b) radar-AMEDAS 24h-rainfall analysis and (c) results of numerical prediction by GSM.

1) Typhoon Man-yi was one of typhoons that made landfall in Japan in 2013. The JMA issued a "special warning" for three Japan prefectures of Fukui, Kyoto and Shiga. Torrential rain caused flood damages around the regions. GSM could not predict rapid intensification of Man-yi.
2) Experimental design

・Computational domain: ~2000 km x ~2400 km

・Horizontal resolution: 2000 m

・Vertical levels: 40 (40 – 1180 m, Top height ~ 23 km)

・Time step 6 seconds in NHM, 36 seconds in the ocean model, 10 minutes in MRI-III

・Initial time: 0000 UTC 14 September 2013

・Oceanic initial conditions. Daily MOVE in 2013 and 2011 for sensitivity numerical experiments.

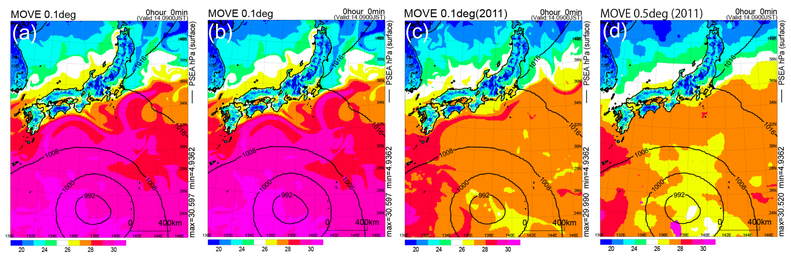


Figure 2 Initial SST from (a) MOVE 0.1 deg. (2013), (b) MOVE 0.1 deg. (2013) (c) as in Fig.2a except in 2011, (d) as in Fig. 2b except in 2011

Typhoon Sinlaku (T0813)

1) Typhoon Sinlaku was observed during T-PARC, DOTSTAR and TCS-08 special observations (Yamashita et al., 2010).
2) Experimental design

Analysis and forecast domains: ~3600 km x ~1900 km

Horizontal resolution: 15 km.

Vertical layer: 40 (40 – 1180 m, Top height ~23 km)

Analysis period: from 1200 UTC 1 to 1800 UTC 19 September in 2008.

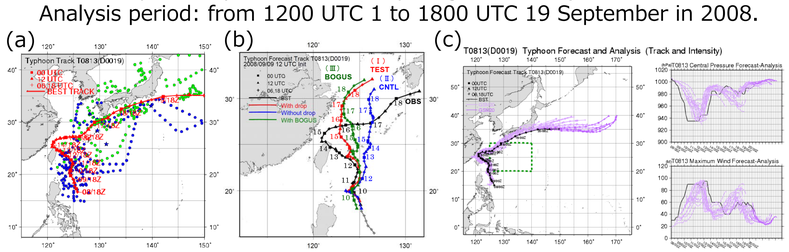


Figure 3 (a) Locations of sonde-observations, (b) track predictions by GSM and (c) Results of numerical predictions by GSM

Results

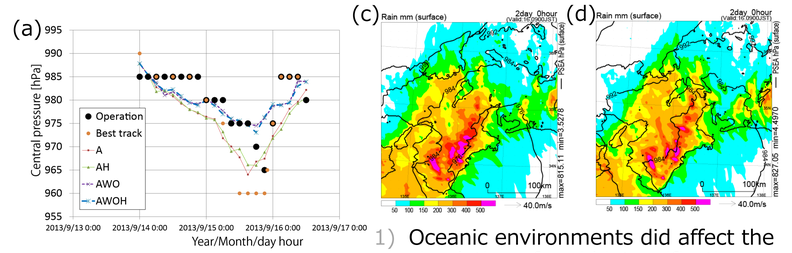


Figure 4 (a) Evolution of simulated central pressures in 2013, (b) as in Fig. 4(a) except in 2011, (c) 24h-rainfall distribution in AH (d) as in Fig. 4(c) except in 2011

1) Oceanic environments did affect the simulation of rapid intensification.
2) The model well simulated torrential rain around the southeastern side of Kii Peninsula.
3) Sea surface cooling by coupled model helped suppress excessive intensification.

a) The coupled model hardly simulated rapid intensification.

b) The model hardly simulated torrential rain around the three Japan prefectures

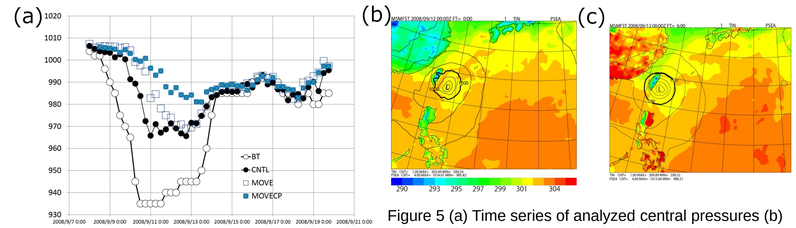


Figure 5 (a) Time series of analyzed central pressures (b) SST distribution at 00 UTC 12 Sep. (b) SST simulation at 06 UTC 12 Sep.

1) Oceanic condition and sea surface cooling did affect the analysis of central pressure of Sinlaku.
2) Sea surface cooling plays a negative role in intensification of Sinlaku.

Discussions

1) Rapid intensification of Man-yi was associated with ocean environments (particularly sea surface cooling).
2) High horizontal resolution (less than 15 km) is needed to analyze rapid intensification and minimum central pressure of tropical cyclones.
3) **Computational resources**. (It took ~three months to perform the numerical experiment using the coupled NHM-LETKF)

References

Kunii, M. (2014). Mesoscale data assimilation for a local severe rainfall event with the NHM-LETKF system. Weather and Forecasting, (2013). http://dx.doi.org/10.1175/WAF-D-13-00032.1.

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