Next generation supercomputer project toward cloud resolving NWP

Kazuo SAITO[1], Hiromu SEKO[1], Tohru KURODA[2,1], Tadashi FUJITA[3], Takuya KAWABATA[1], Kazumasa AONASHI[1] and Tadashi TSUYUKI[1]

[1]*Meteorological Research Institute, Tsukuba, Ibaraki 305-0052, Japan; ksaito@mri-jma.go.jp*

[2]*Japan Agency for Marine-Earth Science and Technology,* [3] *Numerical Prediction Division, Japan Meteorological Agency*

Accuracy of the quantitative precipitation forecast of operational mesoscale numerical weather prediction (NWP) has been remarkably improved in recent years, but precise prediction of heavy rainfalls in unstable atmospheric conditions is still a difficult and challenging subject. Several studies such as development of a cloud-resolving data assimilation system, assimilation of mesoscale remote-sensing observation data (e.g. GPS perceptible water vapor), and development of mesoscale ensemble prediction systems, have been conducted at the Meteorological Research Institute (MRI). Computer resource and observation data are keys to realize full-scale dynamical and probabilistic forecasts of local heavy rainfalls for disaster prevention.

The next-generation supercomputer project, "High-Performance Computing Infrastructure (HPCI) project", is being carried out by RIKEN, with partners in industry, universities, and government institutions, under an initiative by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan. The supercomputer center is being built in the city of Kobe, western Japan (http://www.aics.riken.jp/index_e.html). The supercomputer 'K', in which 80,000 nodes (640,000 cores) of the FUJITSU SAPARC64 processor are installed, will start its operation in April 2011, and the whole system that attains 10 Pflops will be completed in the autumn of 2012. The project consists of five strategic research fields (Life science & medicine, New material & energy, Disaster prevention, Engineering, and Matter & universe), and a five-year research plan of high performance NWP with cloud resolving ensemble data assimilation has been endorsed as one of the sub-project of the Field 3 on the 'K' supercomputer.

The sub-project on mesoscale NWP has following three subjects:

a) Development of a cloud resolving 4 dimensional data assimilation system.
b) Development and validation of a cloud resolving ensemble analysis forecast system.
c) Basic research using very high resolution atmospheric models

The goal of Subject a) is to dynamically predict local heavy rainfalls with deep convection by assimilating dense observation data. A field campaign in the Tokyo metropolitan area will be conducted by MRI and the National Research Institute for Earth Science and Disaster Prevention (NIED) in the summers of 2011-2013 as a possible international test-bed for deep convection. Advanced data assimilation methods such as 4DVAR, LETKF and Ensemble VAR based on nonhydrostatic models in Japan have been developed and applied to case studies of cloud resolving forecast experiments of precipitation. (e.g., Kawabata et al., 2011; Seko et al., 2011; Aonashi and Eito, 2011).

The goal of Subject b) is to show plausibility of the probabilistic quantitative forecast of heavy rainfalls for disaster prevention by cloud resolving ensemble NWP. A NHM-LETKF system using incremental approach (Fig. 1) has been developed at JMA (Fujita et al., 2011) and has been modified at MRI expecting the application to the 'K' computer (Kuroda et al., 2011). Figure 2 shows the ensemble spread of temperature (T) and horizontal wind (U) at 500 hPa by the incremental NHM-LETKF. Amplitude of ensemble spreads is kept significant near the lateral boundaries by introduction of lateral boundary perturbations, of which method was developed at the WWRP B08RDP project (Saito et al., 2011).

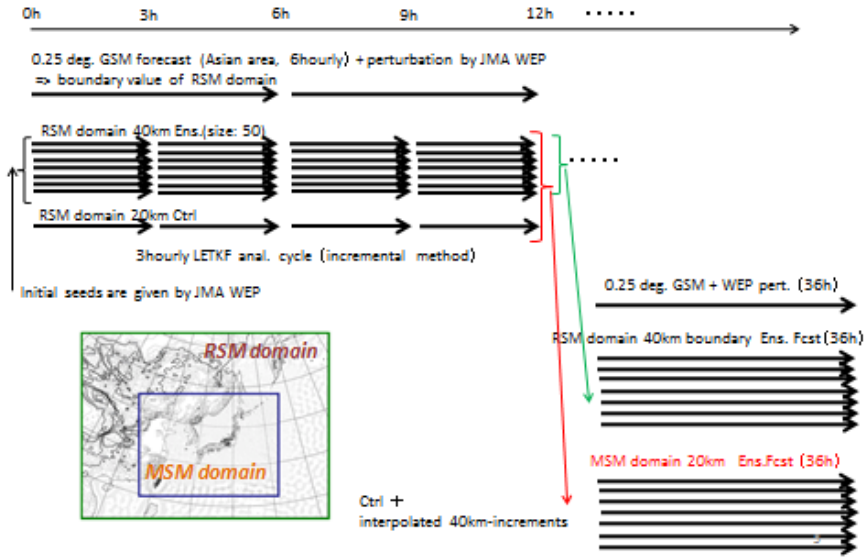

Fig. 1. Schematic diagram of the incremental NHM-LETKF. After Kuroda et al. (2011).

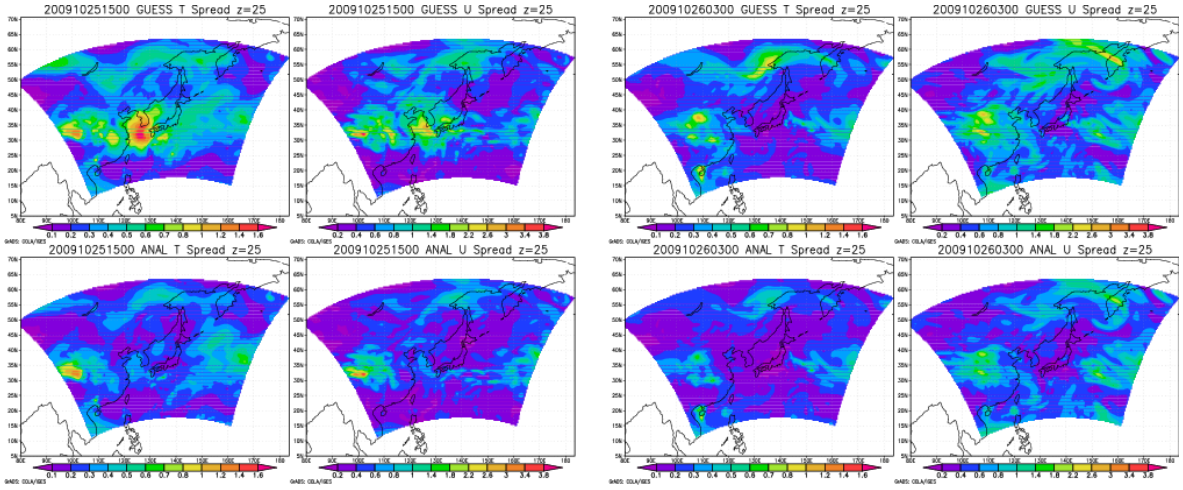

Fig. 2. Ensemble spread of the first guess fields (upper) and the analysis fields (lower) for temperature (T) and horizontal wind (U) at 500 hPa by the incremental NHM-LETKF. Left) 15 UTC 25 October 2009. Right) 03 UTC 26 October 2009. After Kuroda et al. (2011).

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