K-computer project in Japan and super high-accuracy mesoscale weather prediction

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1. Introduction

Accuracy of numerical weather prediction (NWP) has been remarkably improved in recent years (e.g., Saito, 2012), but precise prediction of severe meteorological phenomena such as torrential rains and local heavy rainfalls is still a difficult and challenging subject. Data assimilation and the ensemble forecast with the cloud-resolving resolution are required, and the computational resource is a key factor to reduce the compromise of the resolutions and ensemble members. The next generation supercomputer, "K", has been constructed in Kobe nu RIKEN (http://www.aics.riken.jp/en/) as a national funded science project of Japan, and the Strategic Programs for Innovative Research (SPIRE) has been started since 2011 under the management of the Ministry of Education, Culture, Sports, Science and Technology (MEXT). A five-year research project on high performance mesoscale NWP is underway as one of the sub-subjects of the Field 3 of SPIRE

(http://www.jamstec.go.jp/hpci-sp/kisyo/kisyo.en.html#kisyo_2).

2. Three research goals

To show feasibility of precise prediction of severe mesoscale phenomena by cloud-resolving models, researches are underway for the following three goals.

1) Development of cloud resolving 4-dimensional data assimilation systems

(by MRI/JMA, JAMSTEC, DPRI/Kyoto Univ., NIED and ISM)

To dynamically predict deep convection and associated local heavy rainfalls, we apply advanced data assimilation methods such as 4D-VAR (e.g., Kawabata et al., 2011) and local ensemble transform Kalman (LETKF; e.g., Seko et al., 2011) to cloud resolving models. Dense observation data such as radar reflectivity, Doppler radar radial winds, GPS slant delay are assimilated in storm scale to obtain more accurate initial conditions. A maximum likelihood ensemble filter using neighbor ensemble and a particle filter based on the nonhydrostatic mesoscale model are also under development.

2) Development and validation of a cloud resolving ensemble analysis and prediction system

(by MRI, NPD, JAMSTEC, DPRI, Tohoku Univ.)

A full-scale regional analysis and prediction system using an incremental LETF is under development (Kuroda et al. 2012). This ensemble data assimilation system shares observation operators with the JMA' s operational nonhydrostatic 4DVAR system, while its target is the quantitative probabilistic forecast for heavy rainfalls using cloud resolving ensemble prediction. Results of the probabilistic forecast are validated (e.g., Duc et al., 2012) and used as the input data for application systems for disaster prevention such as the ensemble river flow model (e.g., Kobayashi et al., 2012). Super high resolution modelling which nest a building-resolving CFD model with the regional-LETKF is also under way (Chen et al., 2012)

3) Basic research using very high resolution atmospheric models

(by JAMSTEC, MRI, NPD, AORI, Tohoku Univ., DPRI, NDA, HyARC, Tsukuba Univ.）

Uncertainties of the bulk microphysics scheme and the planetary boundary layer parameterization scheme for cloud resolving models are evaluated using very high resolution atmospheric models such as the spectral BIN method and the large eddy simulation models. Very high-resolution simulations of typhoons and tornadoes are also conducted to study mechanisms of their development.

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