Ultra-high Precision Meso-Scale Weather Prediction

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Accuracy of numerical weather prediction (NWP) has been remarkably improved in recent years, but precise prediction of severe meteorological phenomena such as torrential rains and local heavy rainfalls is still a difficult and challenging subject due to the following reasons.

1）Accuracy of initial condition is insufficient for small spatial scale of the severe phenomena.
2）Mesoscale convective systems are often very sensitive to small perturbations of the initial condition and computational conditions.
3）Cumulonimbus is not fully resolvable in the horizontal resolution of the current numerical weather prediction systems.

Data assimilation and the ensemble forecast with the cloud-resolving resolution are required to overcome above problems, and the computational resource is a key to reduce the compromise of the resolutions and the number of ensemble members. In this subject, we will perform following three subjects using the "K Computer" and show feasibility of precise prediction of severe mesoscale phenomena by a cloud-resolving NWP system.

1）Development of cloud resolving 4 dimensional data assimilation systems
(by MRI, JAMSTEC, NIED, ISM, DPRI, NPD)

To dynamically predict deep convection and associated local heavy rainfalls, we apply advanced data assimilation methods such as 4D-VAR and local ensemble transform Kalman filter (LETKF) to cloud resolving models. Dense observation data such as radar reflectivity, Doppler radar radial winds, GPS slant delay data 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 forecast system
(by MRI, JAMSTEC, Tohoku Univ., DPRI, Kobe Univ., NPD)

A full-scale regional analysis and prediction system using an incremental LETF is under development. 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 and used as the input data for application systems for disaster prevention such as the ensemble river flow model.

3）Basic research using very high resolution atmospheric models
(by JAMSTEC, MRI, AORI, DPRI, NDA, HyARC, NDA, NPD, AICS, etc.)

"K Computer" allows to simulate the physical processes in much more detail than the conventional numerical weather prediction models. Typical examples of the physical processes are the turbulence in the lower atmosphere and the cloud physics in the precipitation systems. The latter process estimates conversion between cloud particles, rain droplets and snowflakes. Since these physical processes were difficult to directly simulate by the past computer systems, the effects of these processes were estimated by the simplified methods, so called 'parameterizations'. Comparing with the detail simulation by K-computer, we are going to evaluate the error in the parameterizations and improve the mesoscale numerical models.

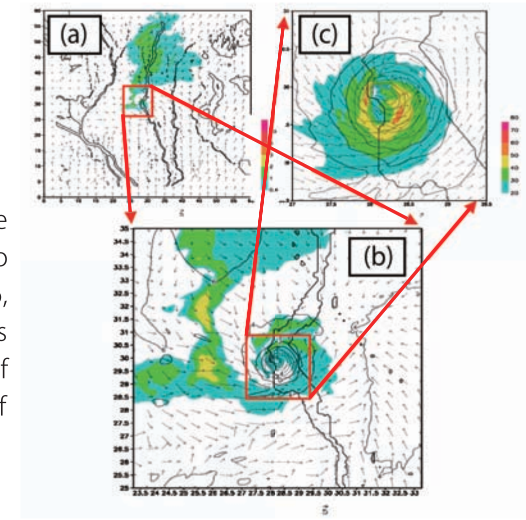
Expected outcome

This study demonstrates feasibility of high precision mesoscale weather prediction using huge computational resources such as the K-computer. Achievements of this study will contribute to progress of future numerical weather prediction and disaster prevention through their technical information.

MRI; Meteorological Research Institute/Japan Meteorological Agency
NPD; Numerical Prediction Division/Japan Meteorological Agency
JAMSTEC; Japan Agency for Marine-Earth Science and Technology
AORI; Atmosphere and Ocean Research Institute/Univ. of Tokyo
NIED; National Research Institute for Earth Science and Disaster Prevention
DPRI; Disaster Prevention Research Institute/Kyoto Univ.
ISM; Institute of Statistical Mathematics,
NDA: National Defense Academy
AICS; Advanced Institute for Computational Science
HyARC; Hydrospheric Atmosphere Research Center/Nagoya Univ.

Development of cloud resolving 4 dimensional data assimilation systems:

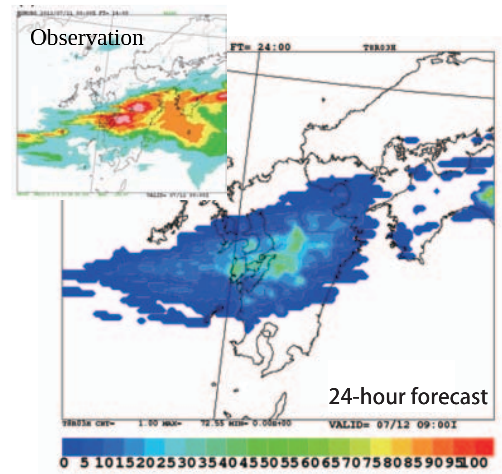
Tadashi Tsuyuki
(Meteorological Research Institute)



A two-way nested assimilation system of the local ensemble transform Kalman filter was developed, and it was applied to the tornadoes that occurred in the Kanto region on May 6, 2012. Right figures show a result of downscale experiments which was obtained by NHM with a horizontal resolution of 50m. Strong wind over 50 m/s caused by the vortex of tornado was well reproduced.
After Seko et al. (2013)

Development and validation of a cloud resolving ensemble analysis and prediction system:

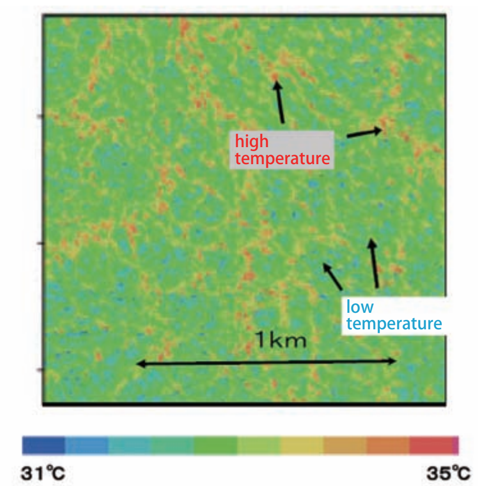
Hiromu Seko
(Meteorological Research Institute)



Ensemble forecast experiments based on the LETKF were conducted for the heavy rainfall case occurred on 12 July over Kyushu district. Right figure illustrates the probability of precipitation occurrence over 50 mm per 3 hours with a lead time of 24 hours. This result exhibits remarkable consistency with the corresponding observation, and suggests it should become a reliable data source for future decision-making.
After Kunii (2013)

Basic research using very high resolution atmospheric models:

Fujio Kimura
(JAMSTEC)



Right figure shows temperature distribution at 2 m high during a sunny day simulated by a LES model. Although the ground surface is uniform, a fish-net-like heterogeneous distribution is formed with the amplitude of about 3 K. We are going contribute to improve the accuracy of the estimation methods for the exchange of heat, moisture and momentum between atmosphere and land/sea surfaces as well as the transport processes in the lower atmosphere.
After Ito et al. (2013)