An operational high resolution regional NWP system at JMA

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1. Introduction

- The supercomputer system at JMA has been upgraded in June 2012, and now in operation.
- Taking advantage of much more computational resources, a high resolution (dx=2km) regional model (LFM: Local Forecast Model) has been operating.
- The purpose is Providing information on
  - Aviation weather (local forecast near airports)
  - Disaster prevention caused by heavy rain, strong wind, and so on
  - Input to Very Short Range Forecasting of Precipitation (which combines extrapolation of observations and model forecasts)
- The contents of this presentation are as follows:
  - Brief introduction of the new supercomputer system
  - A basic design including production of initial conditions
  - Advantages of the operational high resolution model
  - Some typical examples of products of the system

2. The new supercomputer system at JMA (Table. 1)

- Total Peak Performance: about 30 times
- Completely dual and symmetric system

Table 1. Comparison between the previous and new supercomputer system at JMA

	Mar. 2006- Jun. 2012	Jun. 2012 –
	HITACHI SR11000 	HITACHI SR16000/M1 
Total Peak Performance	27.584TFlops（134.4GFlops/1node）	847TFlops（980.5GFlops/1node）
Total number of nodes	210 nodes（16CPU/1node）	864 nodes（32CPU/1node）
Memory	64GB/node	128GB/node
Memory Bandwidth	134.4GB/s/1node	612GB/s/1node
Network Bandwidth	8GB/s (one-way)	96GB/s (one-way)
System configuration	80nodes x 2 + 50nodes x 1	432nodes x 2

3. Basic design of the Local Forecast Model (LFM)

Domain and topography (Fig. 1)

- Covering Japan and its neighborhood with 2km meshes and 60 vertical layers, although currently, the domain is limited to the eastern part of Japan and will be expanded in 2013.
- Lateral boundary conditions of LFM are provided by forecasts of MSM (Meso-Scale Model), which is another operational regional model with 5km meshes and 50 vertical layers.

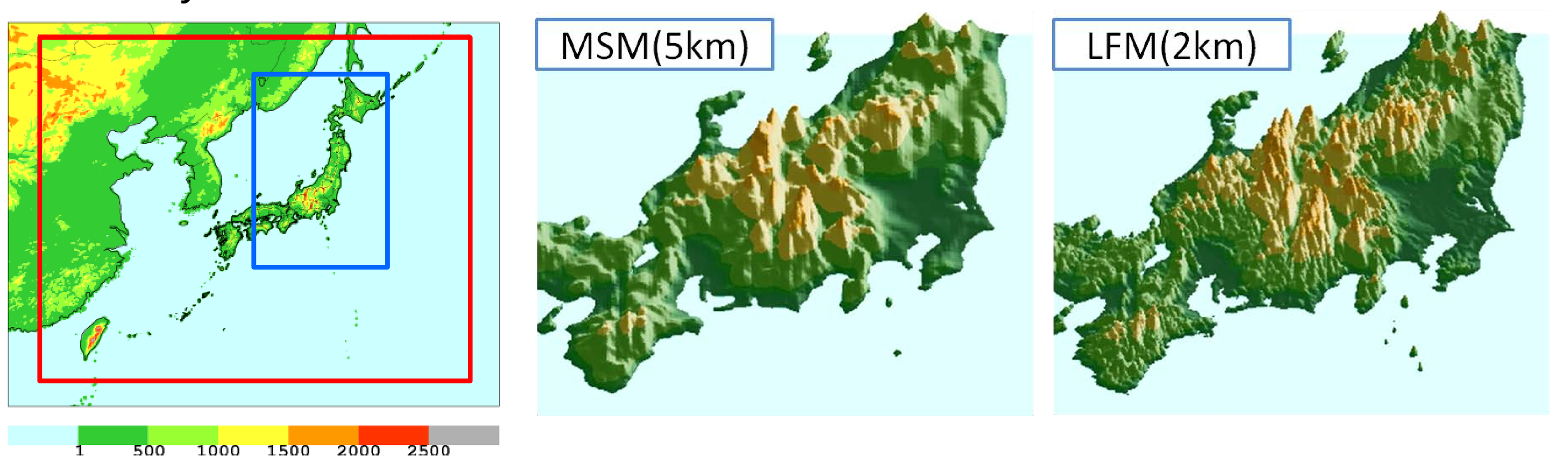

Fig.1 Forecast domain of LFM (Blue: the current limited operation (551x801), Red: full operation in 2013 (1581x1301)) and topography of MSM (dx=5km) and LFM (dx=2km)

Frequency of Updating forecasts, Initial Conditions

- 9-hour forecasts updated every 1 hour (currently reduced to every 3 hours, and will be enhanced in 2013)
- Initial conditions are generated by the rapid update cycle (RUC) employing 3DVAR (Fig. 2).
  - ①The first guess of the 3DVAR at FT= -3 (3 hours before the initial time) comes from forecasts of MSM.
  - ②After the analysis at FT= -3 is obtained by assimilating observations around FT= -3, 1-hour integration from the analysis is conducted to generate the first guess of the next 3DVAR at FT= -2.
  - ③The cycle is repeated, then the final analysis is produced by the final 3DVAR using the first guess obtained from 1-hour forecasts initialized at FT= -1 and observations around FT= 0 (the initial time).
- Assimilating the latest observations and updating forecasts frequently are more emphasized.
- The screened level temperature and wind velocity observed by the surface station (about 900 sites in Japan) are also assimilated.

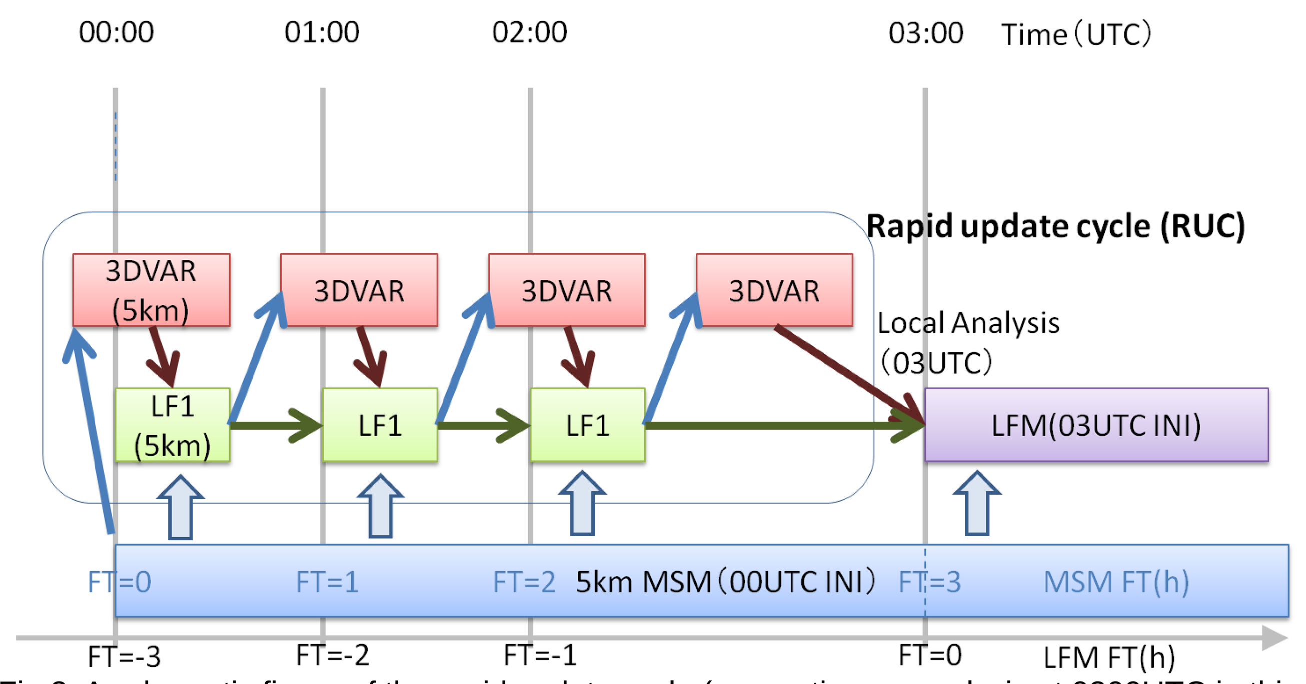

Fig 2. A schematic figure of the rapid update cycle (generating an analysis at 0300UTC in this case). The cycle repeats assimilation by 3DVAR and 1-hour forecasts (LF1). The cycle is executed with 5-km horizontal resolution.

4. Advantages of the high resolution model

- One of the advantages of higher resolution models is that the models can represent smaller scale phenomena.
  - Physical processes employed by LFM used to be almost identical to those in the 5 km MSM (Table 2). Because both of LFM and MSM have been currently employing the identical non-hydrostatic model (JMA-NHM).
  - Only one difference between LFM and MSM is that LFM employs no convective parameterization (Table 2).
  - Because parameterizations of convection are one of the origins of large uncertainty in the model, it is preferable to resolve convective transport using grid-mean vertical velocity if the resolution is fine enough.
  - However, it has been recognized that other physical processes should be also revised depending on its resolution (for example, a method to diagnose cloud fraction in the radiation process was a little bit modified in LFM.).
- Higher resolution models can better represent phenomena related to topography.
  - Orographic lifting is important to initiate convection and mountain waves.
- High resolution makes it possible to assimilate observations of which locality is strong like temperature and wind velocity near the surface.
  - The 3D-VAR in the RUC assimilates 1.5-m temperature and 10-m wind velocity observed by surface stations (called AMeDAS, placed all over Japan).

Table 2. Comparison between the specification of LFM and MSM

	Local Forecast Model (LFM)	Meso-Scale Model (MSM)
Horizontal Resolution	2km (801x551)	5km (721x577)
Vertical Layers	60 Layers, up to 20km	50 Layers, up to 22km
Integration Time Step	8 second	20 second
Initial Condition	Local Analysis (LA) JNoVA 3D-Var	Mesoscale Analysis (MA) JNoVA 4D-Var
Boundary Condition	MSM	GSM
Forecast hours	9 hours	33/15 hours
Cloud Physics	Mixing ratio of cloud, rain, cloud ice, snow, and graupel（Qc, Qr, Qi, Qs, Qg）	Qc, Qr, Qi, Qs, Qg and Number density of cloud ice
Cumulus convective parameterization	Not Used	Kain-Fritsch scheme

5. Typical examples of forecast by LFM

- Figure 3 displays the ability of LFM to predict smaller scale phenomena. LFM represents precipitation brought by small convective cells as observed, while the MSM predicts no such cells.

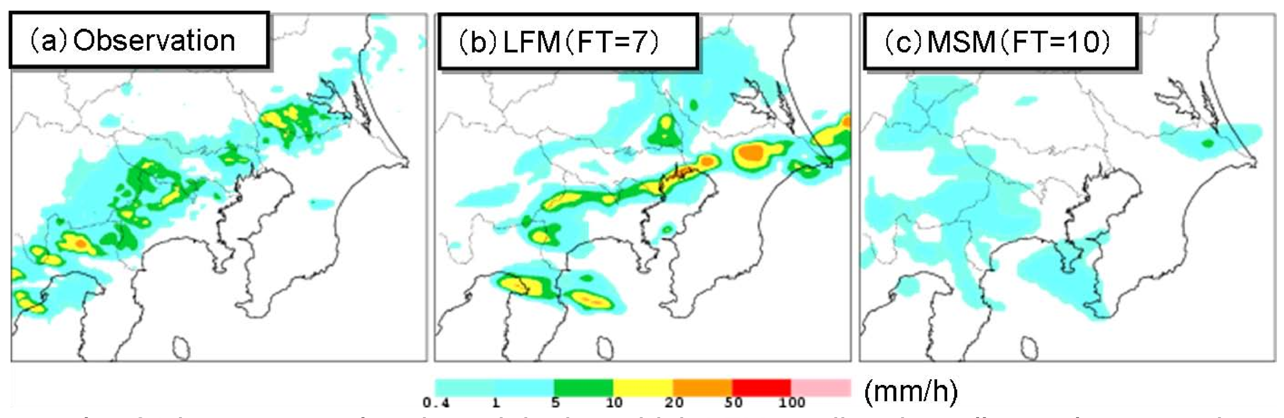

Fig. 3 Typical example of 1 hour accumulated precipitation which LFM predicted smaller scale convective cells than MSM .

- Figure 4 displays the ability of LFM to predict orographic precipitation. The LFM can better represent precipitation generated by orographic lifting.

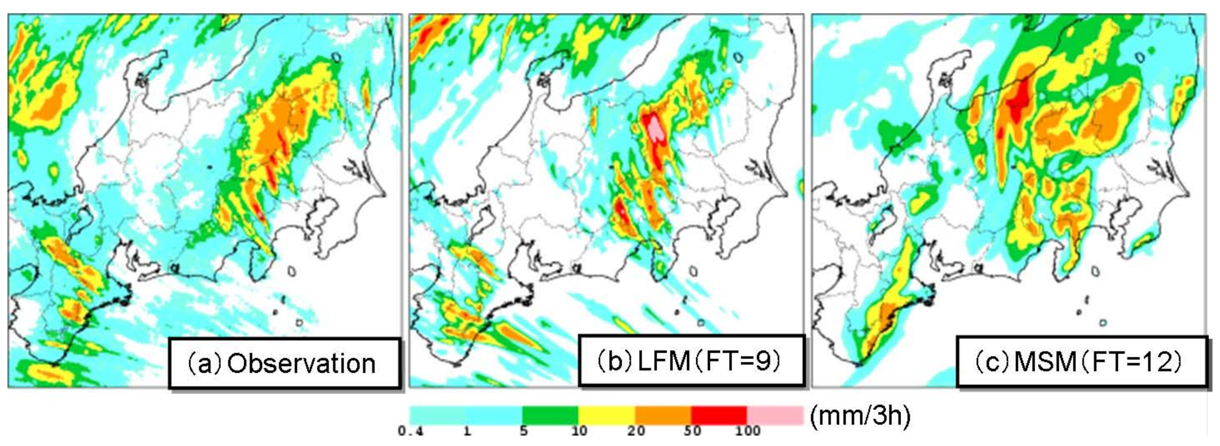

Fig. 4 Typical example of 3 hour accumulated precipitation which LFM better predicted orographic precipitation than MSM.

- Figure 5 shows impacts of assimilating observations near surfaces. One can find that (b) shows more coincidences between observations and analysis than (c).

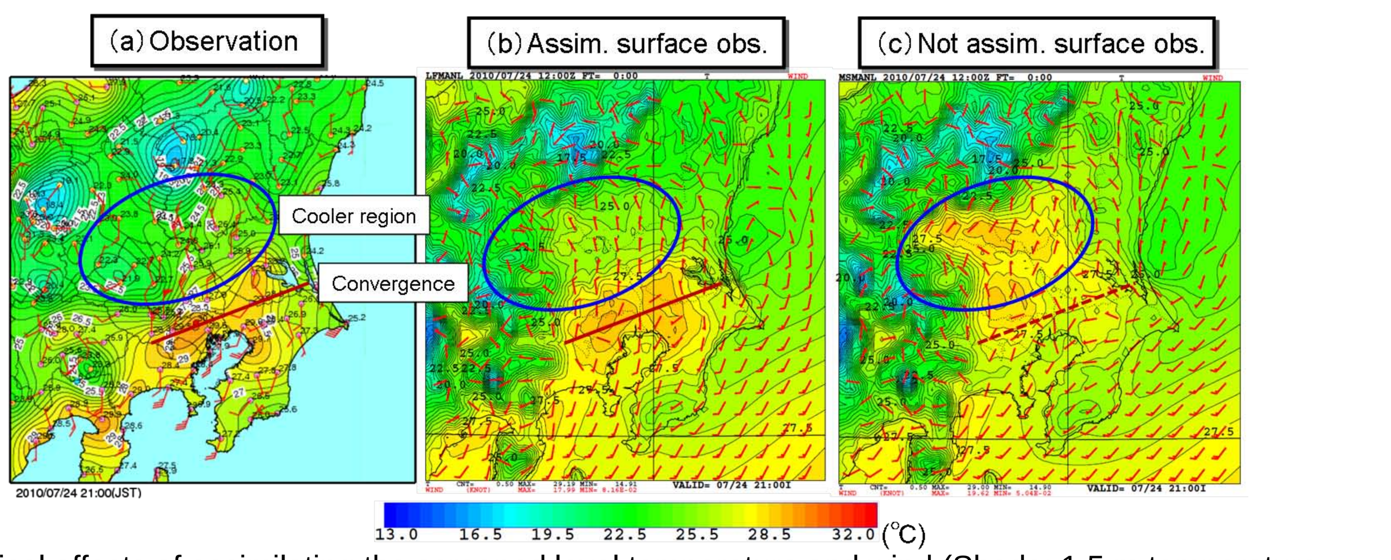

Fig. 5 Typical effects of assimilating the screened level temperature and wind (Shade: 1.5 m temperature, Wind barb: 10m wind). The position of the convergence line was corrected as well as temperature distribution.

6. Future plans

- The forecast domain will be expanded so that the Japanese territory and its surrounding areas can be covered (Fig. 1) and the update frequency will be enhanced to every hour in 2013.
- We continue to develop and improve the NWP system (e.g., a next generation dynamical core "ASUCA" with "the Physics Library" (Hara et al. 2012)) and the assimilation methods of observations (e.g., 1D+3VAR using the retrieved RH from radar reflectivity (Ikuta 2012)).

References

Hara, T., K. Kawano, K. Aranami, Y. Kitamura, M. Sakamoto, H. Kusabiraki, C. Muroi, and J. Ishida, 2012: Development of the Physics Library and its application to ASUCA. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **42**, 5.05-5.07.

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