Development of the Operational Data Assimilation System for Rapid and Frequent Updates of Forecast with the Convection-Permitting Model at JMA

Tadashi Fujita, Yoshihiro Ishikawa, Yasutaka Ikuta, Kosuke Ono, Kensuke Ishii, Koichi Yoshimoto, Junichi Ishida, Tabito Hara, Kohei Kawano, Haruka Kurahashi, Kengo Matsubayashi, Nobumiki Kinoshita, Takumu Egawa, Yuki Kosaka and Hisaki Eito

Numerical Prediction Division, Japan Meteorological Agency
Local NWP System (LA + LFM)

- Objectives: providing information for aviation weather forecast and disaster prevention, with emphasis on forecasting severe events
- High resolution NWP: Grid spacing of 2km (the finest in the JMA’s operational NWP system)
- High frequency operation: 24 times a day (hourly)
- In operation from Aug. 2012

**Global NWP System**
- Global Spectral Model (GSM)
- Global Analysis (GA)

**Meso-Scale NWP System**
- Meso-Scale Model (MSM)
- Meso-Scale Analysis (MA)

**Resolution**
- ~20km
- 5km
- 2km

Domain 1581 x 1301 covering the whole Japan
# Local NWP System (LA + LFM)

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<th>Forecast Model</th>
<th>Local NWP System</th>
<th>Meso-Scale NWP System</th>
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<td>20 second</td>
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<td>GSM</td>
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<td>Qc, Qr, Qi, Qs, Qg and Number density of cloud ice</td>
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<td>Vertical Layers</td>
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<td>Inner/Outer: 40/50 Layers up to 22/22km</td>
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<tr>
<td>Cutoff time</td>
<td>30 minutes</td>
<td>50 minutes</td>
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</tbody>
</table>
Features of the Local NWP System

- **High resolution**
  - Explicit representation of spatial and temporal variations at fine scale
  - More realistic terrain
    - help resolve terrain induced phenomena
    - mitigate representativeness error in use of surface observations

- **High frequency**
  - Frequently provide an enhanced forecast with information from the latest observations.
  - Hourly operation of rapid forecasts using an efficient system.
LFM predicts two line shaped heavy precipitation areas. High resolution helps better representing the strong vertical transportation of convection.

14 Jul. 2012  01UTC 1-hour accumulated precipitation
Features of the Local NWP System

High Frequency Operation

Local NWP System: High Frequency Operation

- Hourly update of forecasts initialized using the latest observations.
- LFM Results become available by initial time +70 min. (compared to +150min for MSM)
Features of the Local NWP System
High Frequency Operation

Updates of Forecasts valid at 7/11 18UTC from different initial times (1h accumulated precipitation)

Lead Time

470min 410min 390min 350min 290min 230min 210min 170min 110min 50min

Frequent updates reflecting newly received observations. Results available by initial time + 70min.

3 hourly updates. Results available by Initial time +150min.
LA system

- assimilate the latest observations through 3h analysis cycle (iterate 3D-Var + 1-hour forecasts)
- use MSM forecast (initialized with 4D-Var) as the first guess
- Data Cut off time: 30 minutes, Resolution: 5km, 50 vertical levels
### LA system

**Observations Assimilated to Initialize JMA Operational Forecast Models**

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<thead>
<tr>
<th>Kind</th>
<th>P</th>
<th>T</th>
<th>UV</th>
<th>RH</th>
<th>IPW</th>
<th>RR</th>
<th>Doppler Velocity</th>
<th>Radiance</th>
<th>Refractivity (Angle of Refraction)</th>
<th>Delay</th>
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<tbody>
<tr>
<td>Land Surface Observations</td>
<td>G</td>
<td>M</td>
<td>L</td>
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<td>Automated Weather Stations</td>
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<td>Doppler Radar</td>
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<td>Radar/Rain Gauge-Analyzered Precipitation</td>
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**Direct Observations**

- LA makes extensive use of surface observations.
- Remote sensing data are used as important sources of detailed information for forecasting high impact events.
- Development is in progress for introduction of satellite data (Brightness Temperature and Atmospheric Motion Vector).

Extensive use of data with high temporal resolution (rapid scan satellite data, etc.) is considered to be an important challenge in the future.

G: Global Analysis, M: Meso-scale Analysis, L: Local Analysis

( ) : under development for introduction
6th WMO Symposium on Data Assimilation

LA system: Distribution of Assimilated Observation Data

30 Sep. 2013 00UTC
LA system

Use of radar reflectivity observation

MSM → Radar simulator → Radar obs.

Ze-RH Database → Ze

Kernel Density Estimation of PDF + Maximum Likelihood Estimation

RH pseudo obs. → 3DVAR → LF1

Estimated RH PDF for different values of Ze

Altitude 3000m

3h accumulated precipitation 27 Jul. 2011, 18UTC

Ongoing Development: enhancement of LA cycle

Test to enhance resolution of the last 1h forecast.

Operational System

Test System

Updates of 1h accumulated Precipitation Forecasts (all valid at 06 Jul. 2012 11UTC from different initial times)

Contribute to improve spin-up of precipitation forecast, mitigating shock from different resolutions.
Ongoing Development: asuca-Var

JMA has started to develop a new framework of forecast and analysis systems.

**asuca**: new dynamical core

**Physics Library**: a repository of various physical process routines with unified specification

**asuca-Var**: Variational data assimilation system based on “asuca”

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**asuca**

**(NL,TL,AD)**

**Physics Library**

**(NL,TL,AD)**

**asuca-Var core**

- 3D-Var
- 4D-Var
- +Hybrid

Selector switch is implemented

asuca-Var core is specialized to handle optimization and related processes

**Obs. operator**

**(NL,TL,AD)**

**External packages**

**(NL,TL,AD)**

ex.: RTTOV

**Interface for each observed element**

**Wrapper for each package**

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**Observation**

1h precipitation 11 Jul. 2012, 22UTC

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**asuca-3DVar applied to the Local NWP**

Test system asuca-Var + asuca(5km) => asuca(2km)

Forecast comparable to the operational one

**Operational system**

JNoVA + JMA-NHM(5km) => JMA-NHM(2km)

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organized design and coordinated development of Non-linear, Tangent-linear and Adjoint codes
Ongoing Development
Use of Satellite Brightness Temperature Data

asuca-3DVar Assimilation Experiment

GPS TPW
MTSAT-2 Clear Sky Radiance

MTSAT-2 contributes to greatly increase humidity information over the sea.

Example of MTSTAT-2 Jacobian

$dTb/dqv$

$dTb/dT$

$q_v / q_{bg}$ Increment
Summary

The Local NWP is the finest resolution system in the JMA’s operational NWP system, aimed at providing information on aviation forecast and disaster prevention.

The convection-permitting resolution of LFM allows enhanced prediction of high impact events.

The system is featured with high frequency and rapid updates of forecasts using the latest observations. Use of radar obs. etc. contributes to a better forecast of high impact events.

Various developments are in progress to improve the Local NWP system. These includes:

• enhancement of the LA cycle (high resolution 1h-forecast in the last part of the cycle), contributing to improve spin-up of precipitation forecast.
• development of a new framework of forecast and analysis systems (asuca and asuca-Var), achieving a comparable performance with the current operational Local NWP system.
• introduction of satellite observations (TB, AMV), contributing to greatly increase observation coverage.