Recent Development of meso scale NWP system at JMA

Junichi Ishida, Tabito Hara, Kohei Aranami, Kohei Kawano, Kengo Matsubayashi, Hiroshi Kusabiraki, Haruka Kurahashi, Takahiro Ito, Tadashi Fujita, Yoshihiro Ishikawa, Junya Fukuda, Yasutaka Ikuta, Kosuke Ono, Nobumiki Kinoshita, Tooru Tsukamoto and Hisaki Eito

*Numerical Prediction Division, Japan Meteorological Agency (NPD/JMA), 1-3-4 Chiyoda-ku, Tokyo, Japan, 100-8122 e-mail: j-ishida@met.kishou.go.jp

1. Operational meso scale NWP system at JMA

JMA operates two regional models (Fig. 1).

- Meso-Scale Model (MSM); 8 times a day, dx of 5km, covering Japan and its surroundings since 2006.
- Local Forecast Model (LFM); 24 times a day, dx of 2km, covering Japan and its surroundings since May 2013.

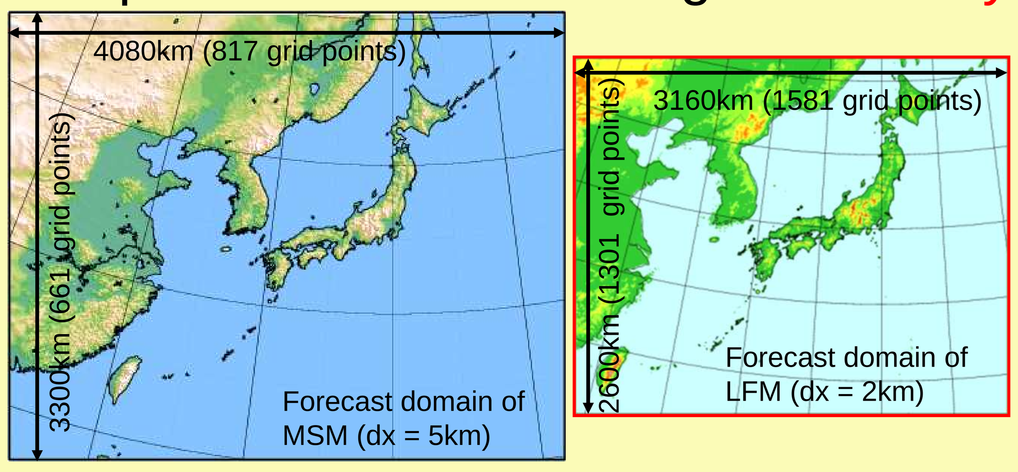

Fig. 1: A forecast domain of MSM (left) and LFM (right). Both systems cover Japan and its surrounding region.

- Forecast Model
  - MSM and LFM employ JMA-NHM as forecast model.
- Data Assimilation system
  - JNoVA (JMA-NHM based 4D-Var) provides initial fields for MSM.
  - Initial conditions of LFM are provided by a 3-hour analysis cycle combining the 3D-Var and 1-hour forecast . Its first guess comes from the MSM forecast (Fig. 2).

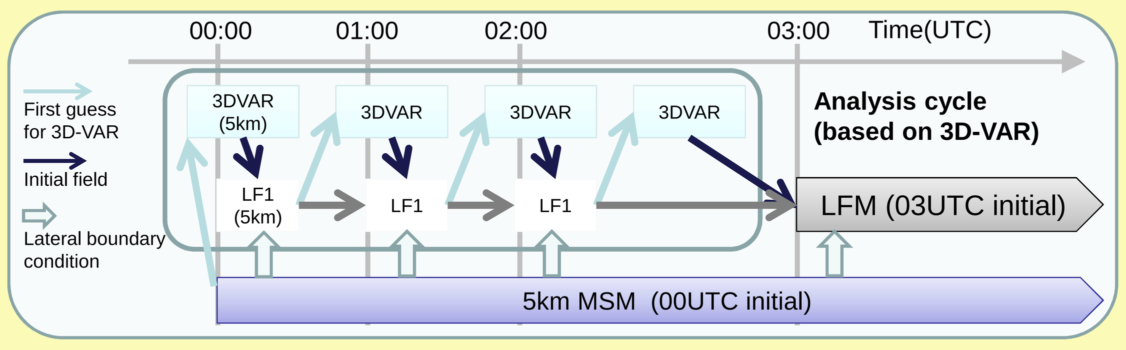

Fig. 2: A schematic diagram of the data assimilation system which provides an initial field for LFM.

2. Development of new frameworks for meso scale NWP

JMA has been developing three new frameworks to replace the current forecast model and analysis system (Fig. 3).

- ASUCA: new dynamical core: developing since 2007
  - Improved computational stability,
  - Higher efficiency on massive parallel scalar multi-core architecture,
  - Exclusion of artificial parameters such as numerical diffusion, etc.
  - Plan to be employed as LFM in 2014
- Physics Library: developing since 2010
  - Repository for various subroutines related to physical processes with unified coding and interface rules
  - Allows physical processes to be shared among various forecast models
  - More efficient development environment due to the simpler code structures
  - Plan to be employed as LFM in 2014
- ASUCA-Var: three and four dimensional variational data assimilation system based on ASUCA: developing since 2011
  - Collaborative development of Non-linear, Tangent-linear and Adjoint models by numerical modelling and assimilation scientists
  - 3D-Var is planned to be employed as DA system for LFM in 2014.
  - 4D-Var system is under development.

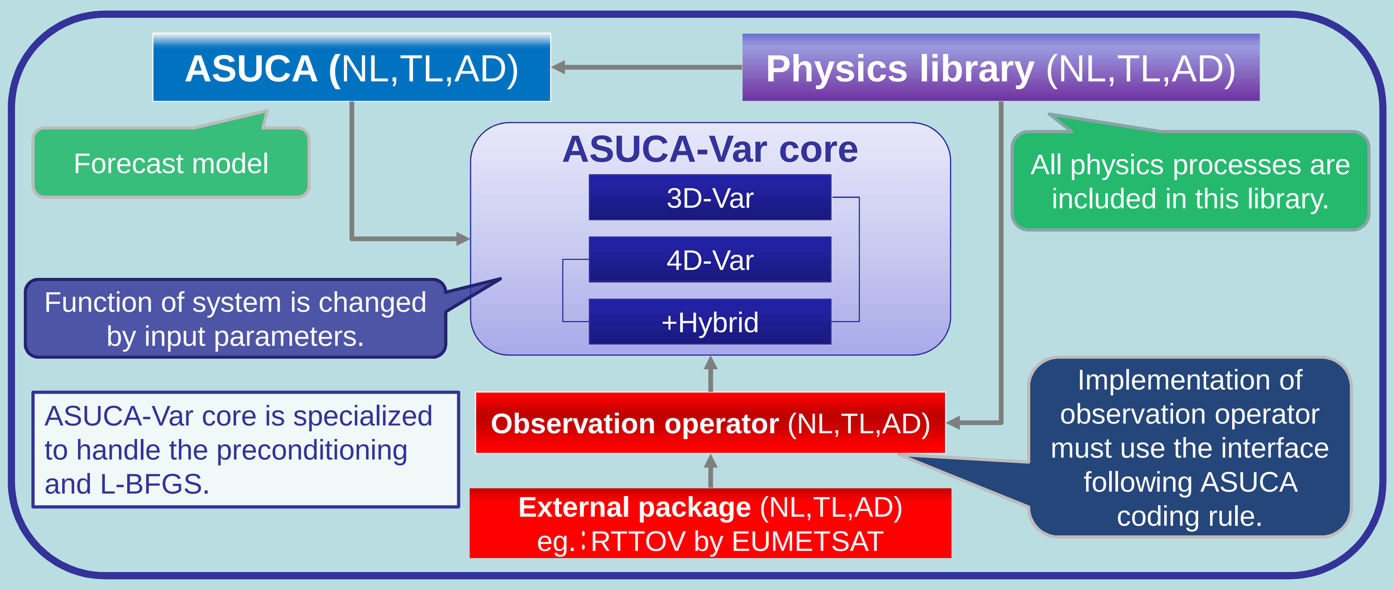

Fig. 3: A schematic diagram of the new frameworks (ASUCA, Physics Library and ASUCA-Var) for meso NWP system

3. Development of Meso Ensemble Prediction System

- Meso Ensemble Prediction System (MEPS) will be in test operation in the 1st Quarter of 2015 (Fig. 4).
- Specifications (test operation)
  - Resolution and Domain: 5km and 4080x3300km (same as MSM)
  - Ensemble size: 11
    - 10 perturbed forecasts and 1 control forecast
  - Perturbation
    - Initial condition: Singular Vector (SV)
    - Lateral Boundary condition: JMA Global EPS based on SV
    - Physics and lower boundary condition: under development

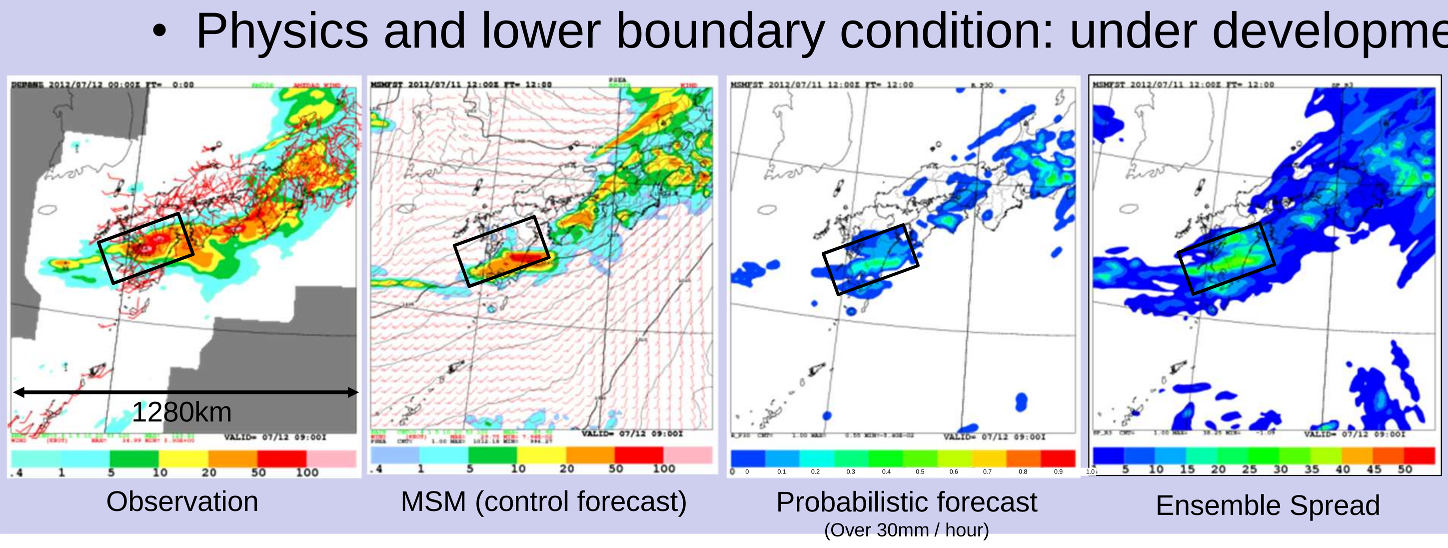

Fig. 4: 3hourly precipitation by observation, control MSM forecast, probabilistic forecast and ensemble spread.

4. Convection in LFM as a cloud permitting model

A cloud "permitting" model cannot treat all phenomena accompanied with convection, though it may resolve a part of them.

Convective parameterizations try to deal with vertical transport, entrainment/detrainment and processes leading to convective initiation (Fig.5).

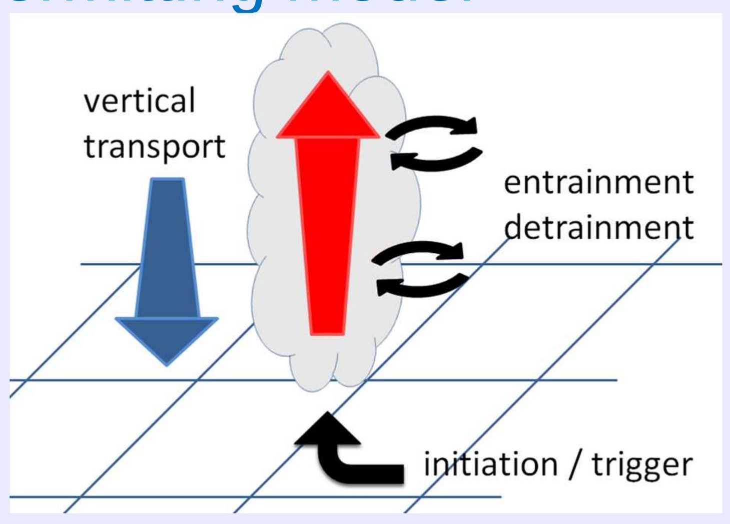

Fig. 5: A schematic model description in convective parameterizations

In a cloud permitting model such as LFM with a grid spacing of 2km …

- Vertical transport: explicitly resolved by grid mean vertical velocity
- Initiation: Part of initiation is controlled by unresolved modes
- Entrainment/detrainment: not resolved

Convective Initiation

- In order to initiate convection, a parcel must be lifted to the LFC overcoming CIN. Forced lifting of parcels usually by convergence, topography, growing mixed layer and so on.
- Convective initiation caused by unresolved modes results delay of convection and too strong updraft of convection (so-called "grid point storm")
- However, high frequency noise can lead to false convective initiation, i.e. the convective initiation is sensitive to advection schemes, strength of numerical diffusion, and so on (Fig. 6).

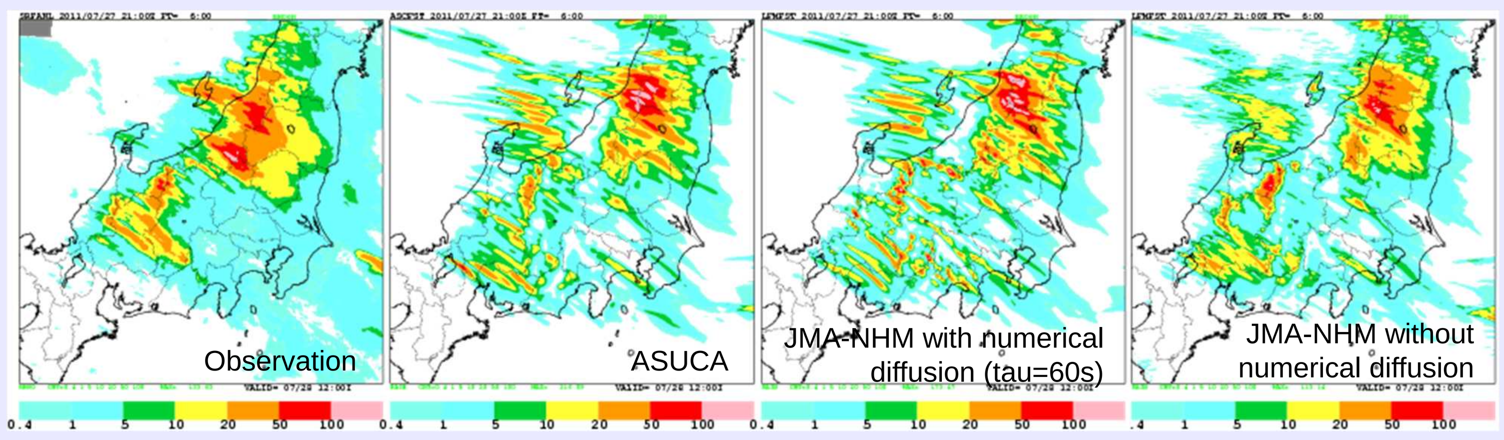

Fig. 6: Sensitivity to numerical diffusion. As the numerical diffusion is stronger, convective cells are shifted to more downstream side, i.e. convective initiation is delayed compared to smaller diffusion case. Convective initiation is affected by unresolved small modes. Unresolved part should be parameterized.

Parameterization for convective initiation (PI)

- Based on the existing convective parameterization (Kain-Fritcsh, employed by MSM), but tendency from convective process is much smaller than the original one (assuming slower convective stabilization).
- At the initiation stage, if the dynamics does not produce updraft due to convection even with unstably stratified layer realized, the parameterization is activated and modifies layer stratification by weakly transporting heat and moisture vertically and releasing latent heat through phase transition of water, resulting in producing local low pressure area.
- Once such local low pressure area is generated, the dynamics of the model calculates convergence into the low pressure area and promotes development of convection.

PI and ASUCA improve the delay of convection and too much convective precipitation (Fig. 7).

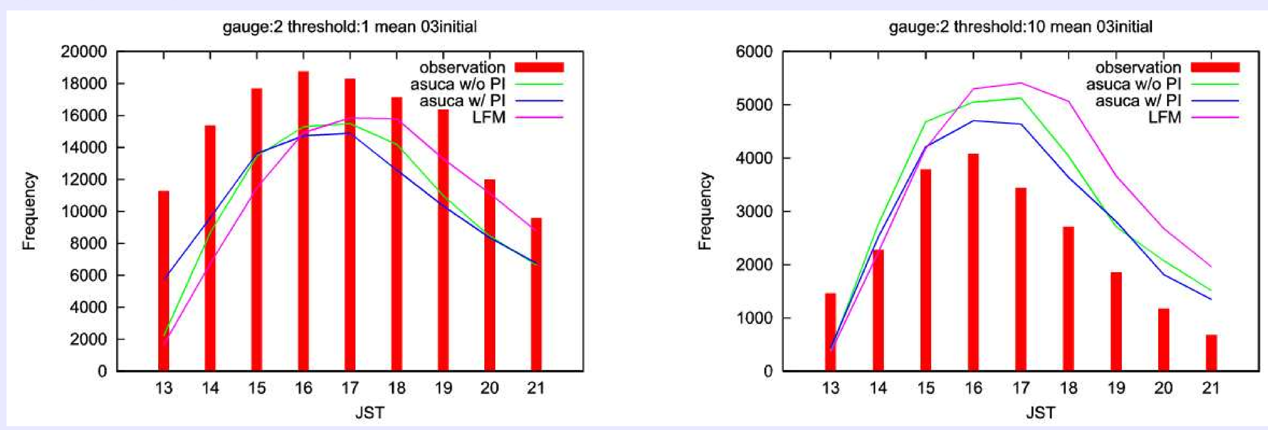

Fig. 7: Time series of precipitation frequency. Red bars indicate observation. Pink line indicates LFM (current model). Green and blue lines show ASUCA without PI and ASUCA with PI, respectively. Even without PI, ASUCA improves peaks of frequency compared with LFM. By employing PI, peaks of frequency almost coincide with observed ones.

5. Change of MSM model top height and vertical resolution

JMA has a plan to raise model top height (from about 22km to about 37km (5hPa)) and increase number of vertical layers from 50 to over 75 of MSM to aim

- More effective use of satellite observation
- More detailed treatment of physical processes

6. Improvement of Snow Coverage Analysis for MSM

- Snow coverage area of MSM is fixed through the forecast time.
- To improve the initial fields of snow coverage area, JMA is developing new snow coverage analysis system.
  - Method: Optimal Interpolation
  - First guess : Offline SiB (Simple Biosphere model; land model)
  - Observation: SYNOP and AWS in Japan
  - Plan to be in operation before this winter.
- JMA is also developing SiB to implement in ASUCA.