Development of limited-area NWP systems at JMA

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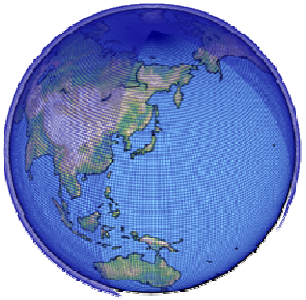
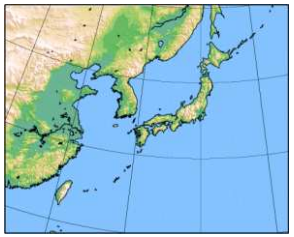
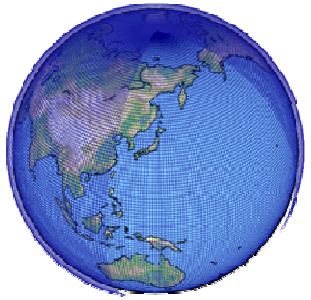
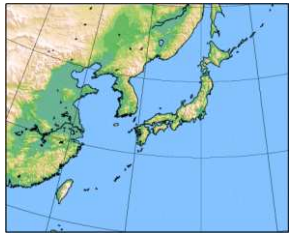
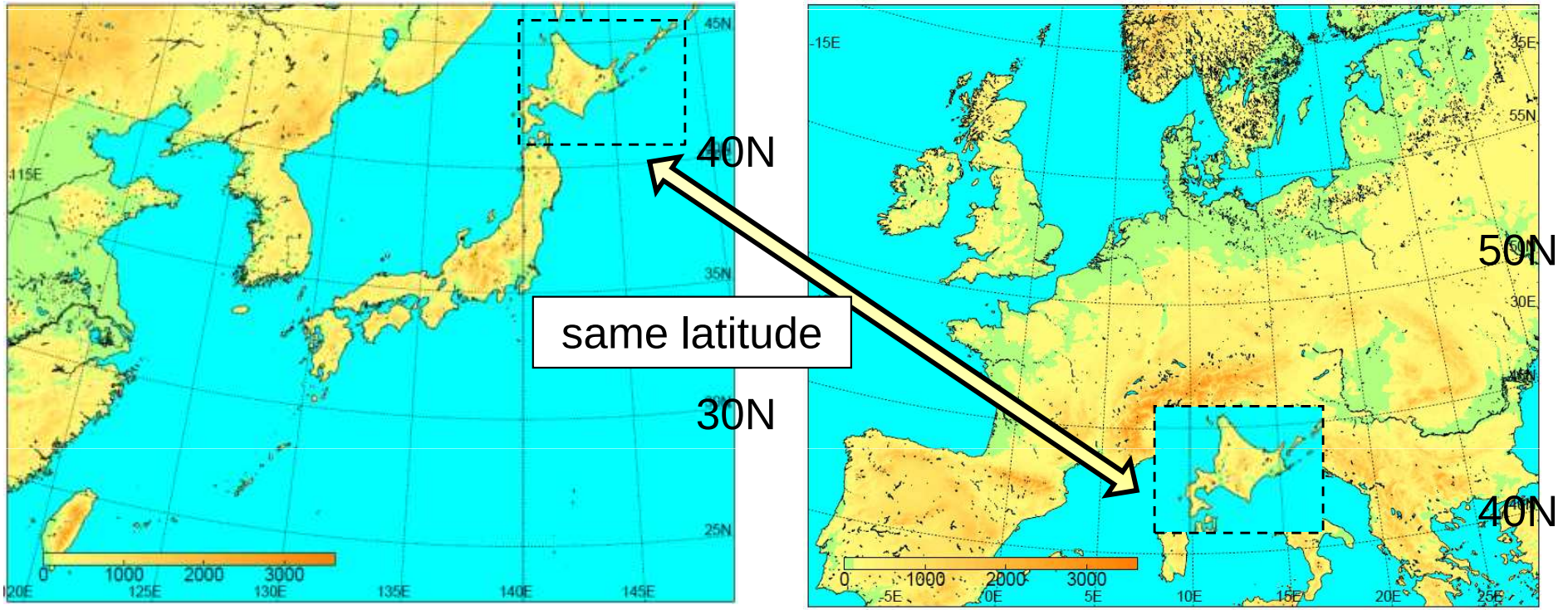
Current NWP models of NPD/JMA

	In Operation					In Test Operation
	Global Spectral Model **GSM**	Meso-Scale Model **MSM**	Local Forecast Model **LFM**	One-week Ensemble **WEPS**	Typhoon Ensemble **TEPS**	**Meso-scale Ensemble MEPS**
objectives	Short- and Medium-range forecast	Disaster reduction Aviation forecast	Aviation forecast Disaster reduction	One-week forecast	Typhoon forecast	Uncertainty and probabilistic information of MSM
Forecast domain	Global 	Japan and its surroundings (4080km x 3300km) 	Japan and its surroundings (3160km x 2600km) 	Global 		Japan and its surroundings (4080km x 3300km) 
Horizontal resolution	TL959(0.1875 deg)	5km	2km	TL479(0.375 deg)		5km
Vertical levels / Top	100 0.01 hPa	48+2 21.8km	58 20.2km	60 0.1 hPa		48+2 21.8km
Forecast Hours (Initial time)	84 hours (00, 06, 18 UTC) 264 hours (12 UTC)	39 hours (00, 03, 06, 09, 12, 15, 18, 21 UTC)	9 hours (00-23 UTC hourly)	264 h (00, 12 UTC) 27 members	132 h (00, 06, 12, 18 UTC) 25 members	39h , 11 members
Initial Condition	Global Analysis (4D-Var)	Meso-scale Analysis (4D-Var)	Local Analysis (3D-Var)	Global Analysis with ensemble perturbations (SV)		Meso-scale Analysis with ensemble perturbations (SV)

Operational high resolution model at JMA

operational domain of LFM

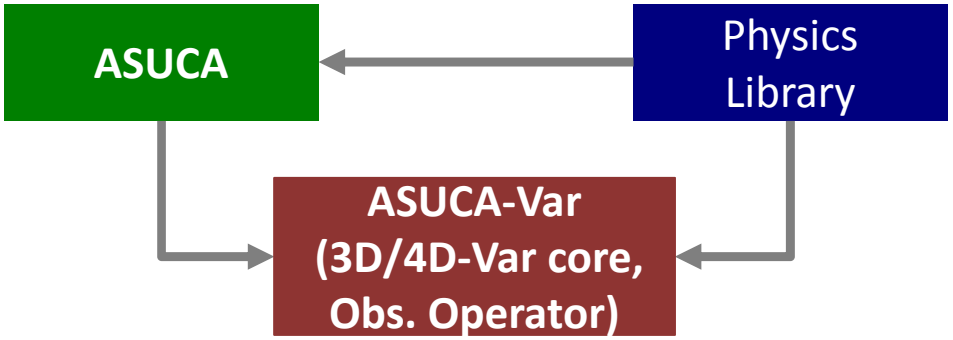
A region of the same size (for reference)



A New Limited-Area NWP Framework: ASUCA

JMA has been developing a new Forecast/DA system "ASUCA", for the next-generation operational Limited-Area NWP Systems.

- ASUCA: new dynamical core: developing since 2007
- Physics Library: repository of highly-portable physical process routines, developing since 2010
- ASUCA-Var: 3D/4D-Var DA system based on ASUCA, developing since 2011



Current Status

- ASUCA and ASUCA-3DVar have been incorporated in the operational Local NWP System since Jan. 2015.
- Development to incorporate ASUCA and ASUCA-4DVar into the Meso-scale NWP System is in progress.

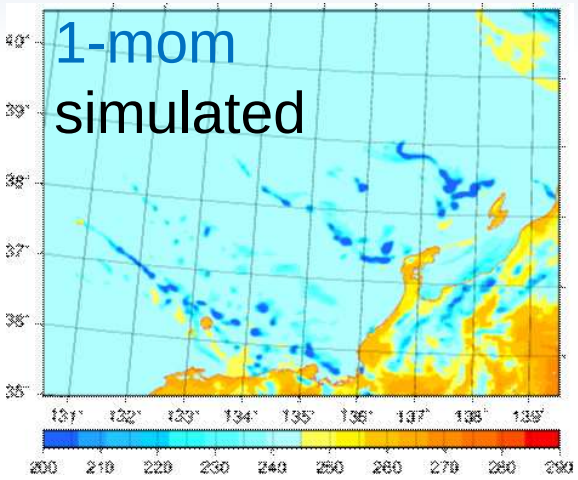
Enhancement of Microphysics Scheme (PSD of snow aggregates)

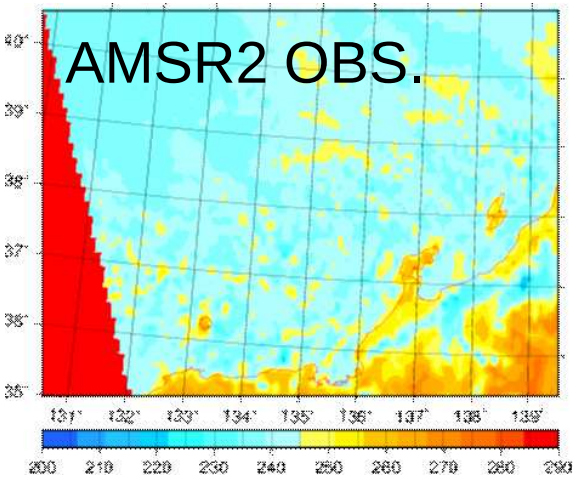
Impacts of changing PSD on simulated TBs of 89GHz vertically polarized microwave image (sensitive to relatively large ice particle such as snow) are investigated.

Operational LFM (1-mom. bulk microphysics)

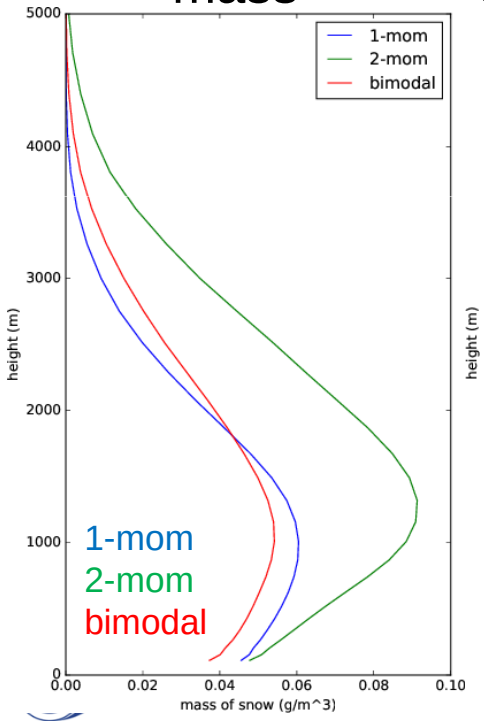
* Simulated TB is often too low

Over almost all the layers, num. conc. of snow is very small.
=> too large effective radius

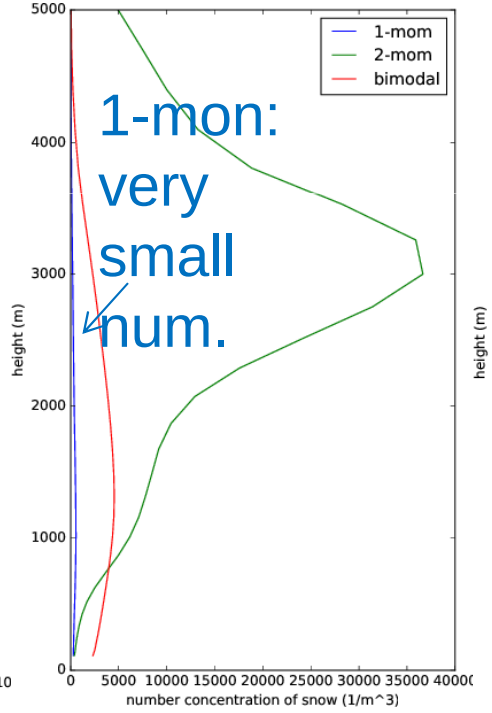




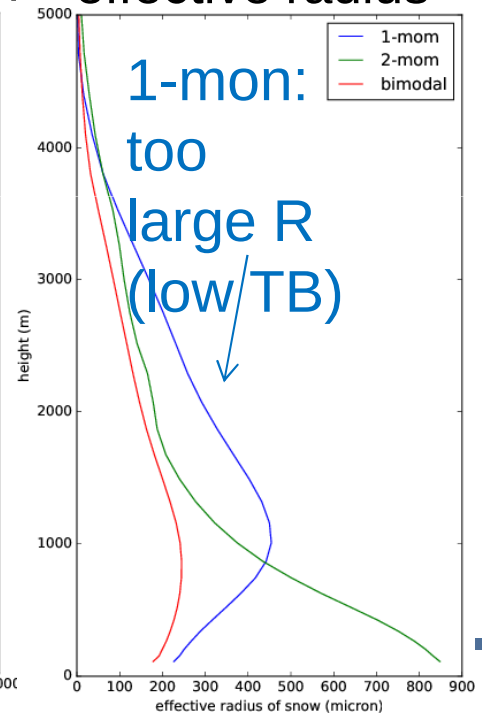
mass



num. concentration



effective radius



(Simulations used the Joint Simulator, developed in collaboration with scientists in JAXA, universities and institutes in Japan.)

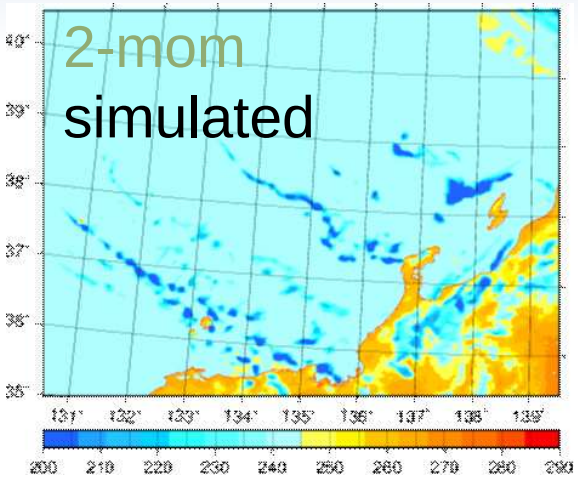
Enhancement of Microphysics Scheme (PSD of snow aggregates)

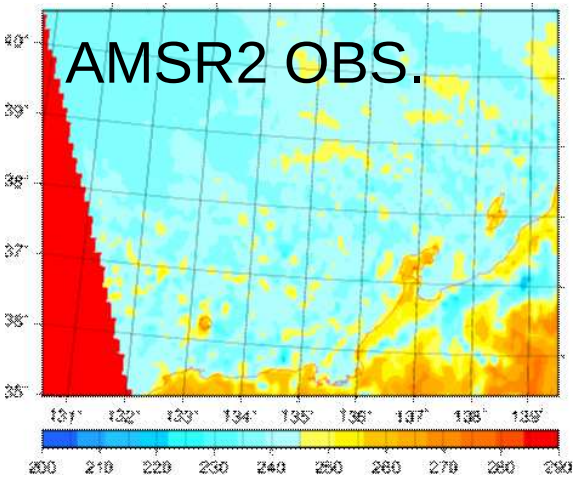
2-mom. Scheme (based on Ikawa and Saito (1991))

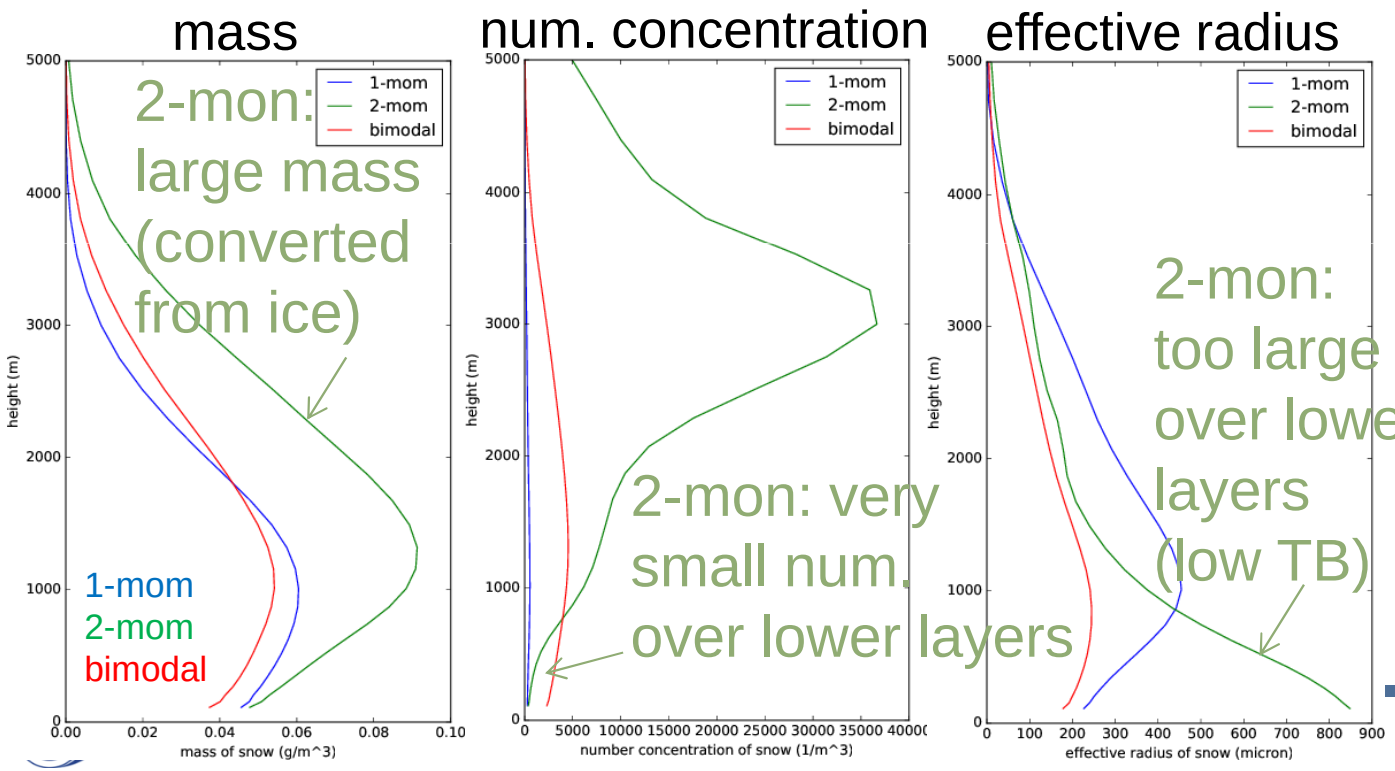
* Num. conc. is predicted in addition to mass.

    * Num. conc. dramatically changes, But simulated TB is still too low

* Too low num. conc. over the lower layers
  => Too large effective radius
* 2-mom. scheme has extra degrees of freedom to represent PSD. But they have to be well controlled.







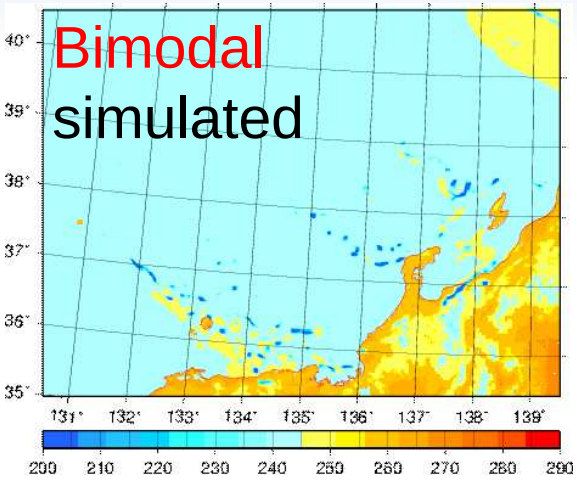
(Simulations used the Joint Simulator, developed in collaboration with scientists in JAXA, universities and institutes in Japan.)

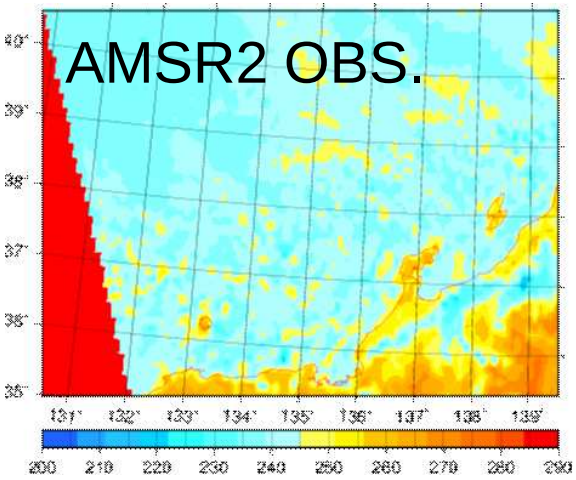
Enhancement of Microphysics Scheme (PSD of snow aggregates)

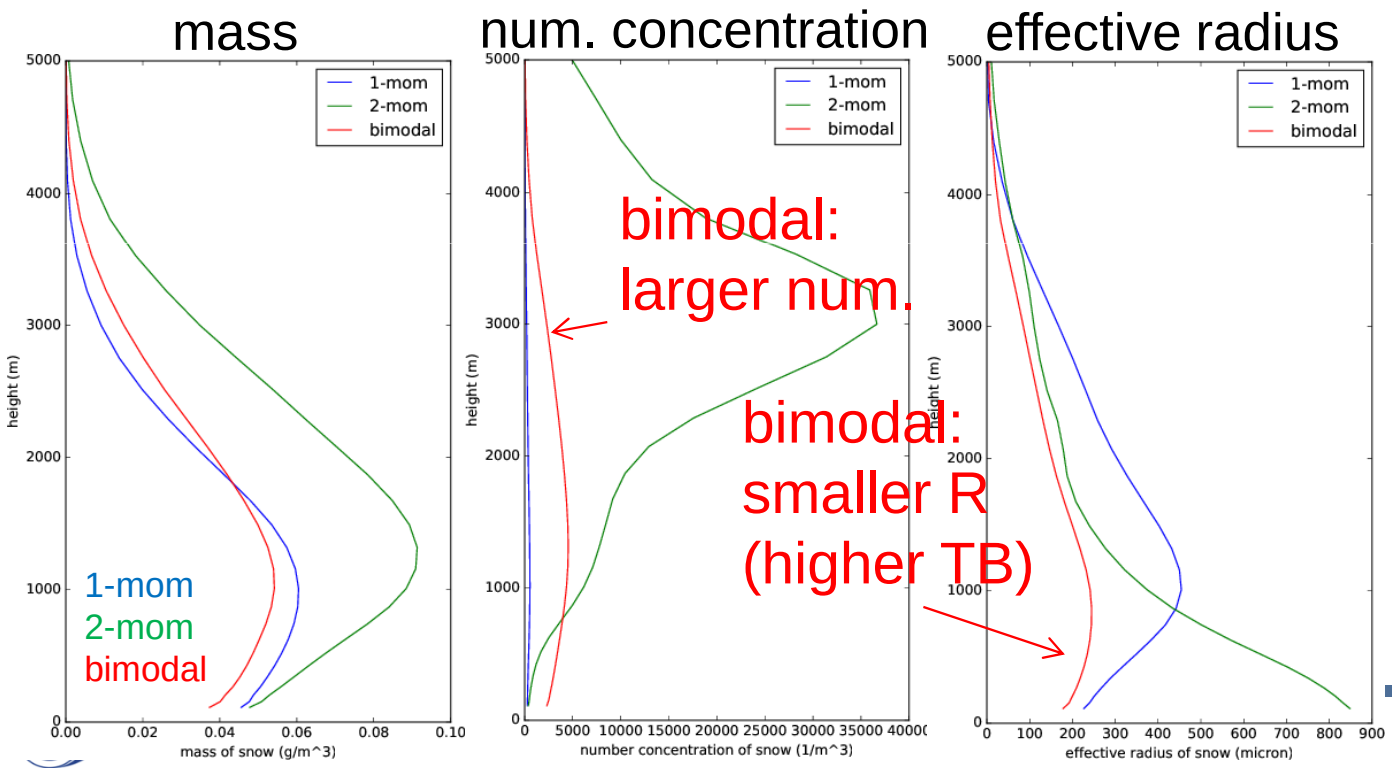
1-mom. scheme enhanced with the bimodal PSD (based on Field et al. 2007)
* Based on aircraft obs. T-dependency of PSD is also implemented. Mass is taken to be proportional to D^2 (instead of D^3).

Smaller and realistic effective radius.
=> The low TB cells disappear.

The result by bimodal PSD, with less degrees of freedom, agrees to obs. better than that by 2-mom.







(Simulations used the Joint Simulator, developed in collaboration with scientists in JAXA, universities and institutes in Japan.)

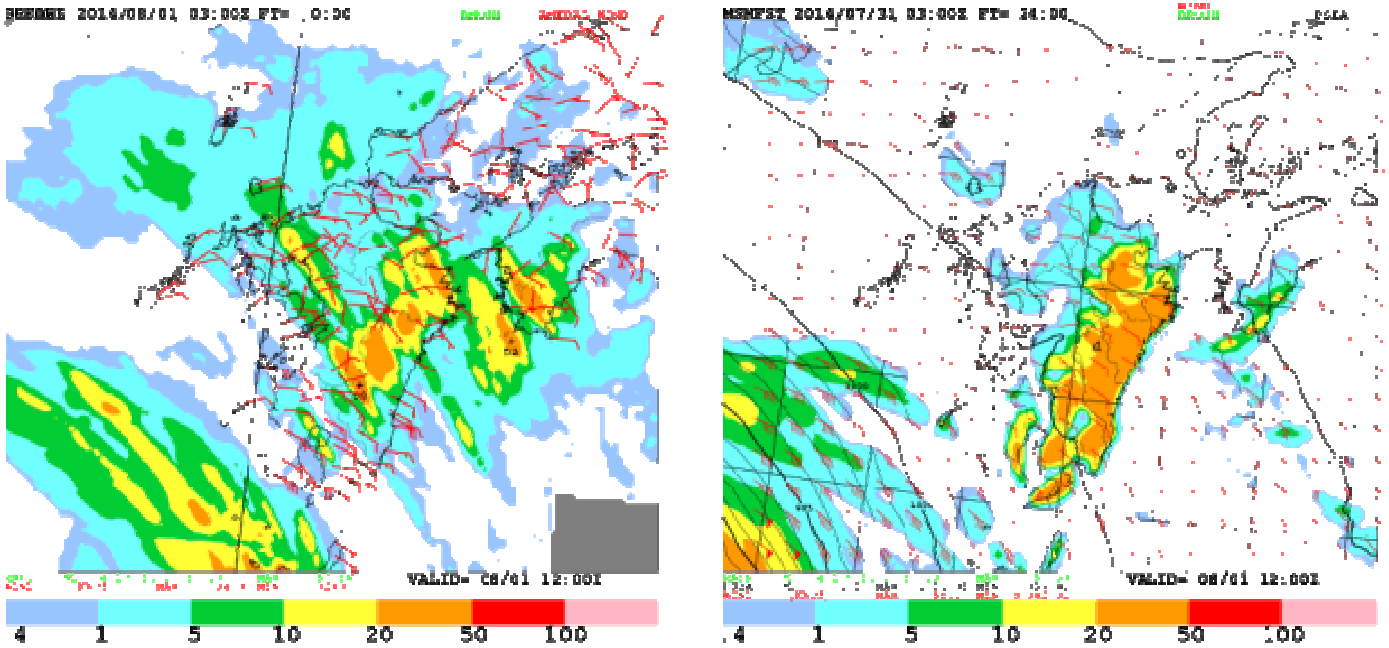
Enhancement of Convective Parameterization Scheme

Precipitation forecast from the current MSM (JMA-NHM).
* too little precipitation over the sea. (weak w)
* precipitation localized over up-wind side of mountain slopes. (terrain intensified w)

Initiation is likely triggered by smaller scale phenomena.
=> Reconsideration of MSM convective parameterization (KF scheme).

observation

JMA-NHM (operational MSM) FT=24h



3h accumulated precipitation
1 Aug. 2014 03UTC

Enhancement of Convective Parameterization Scheme

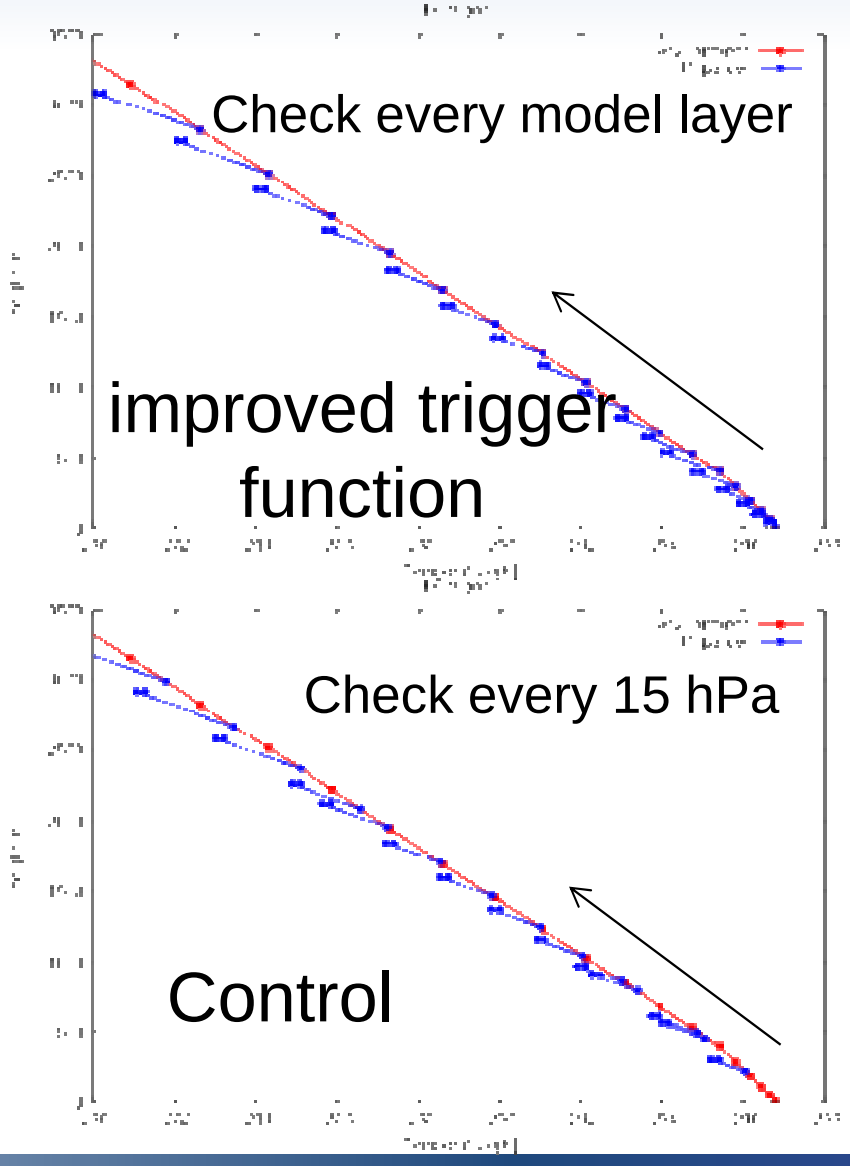
Reconsideration of MSM convective parameterization (KF scheme).

* parcel Temperature perturbation
  based on grid-resolved w
  => based on PBL profiles
  (based on sub-grid processes)

* Identification of updraft source layer
  with 15hPa interval
  => every model layer
  (higher vertical resolution)

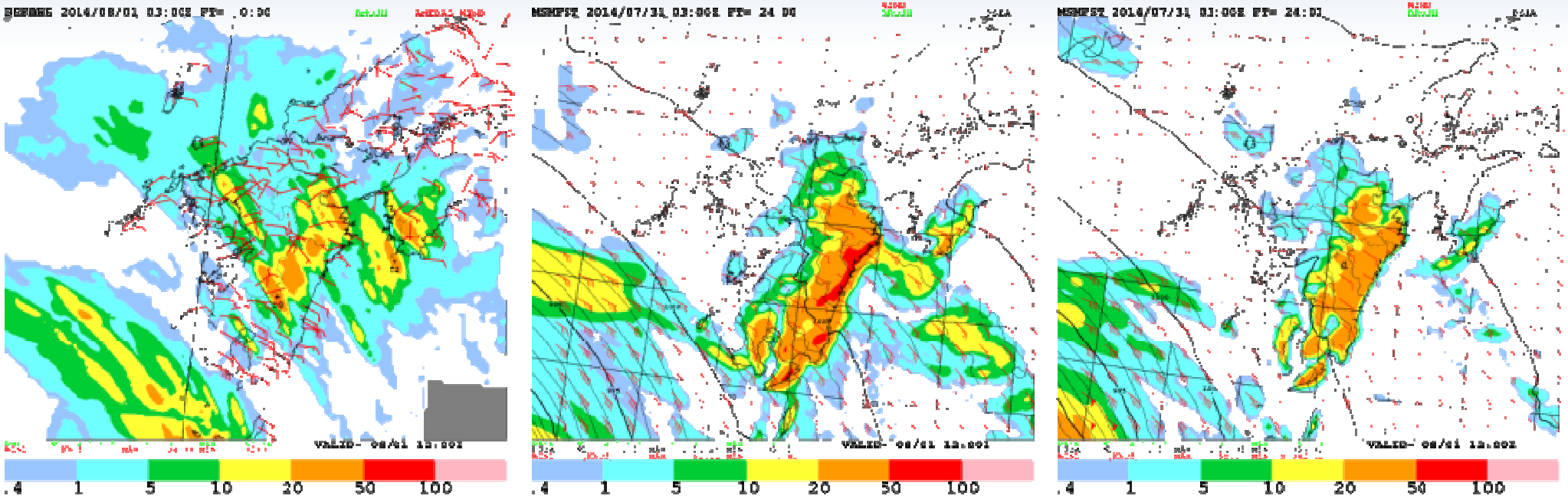
* Updraft parcel profile
  averaged over 50hPa
  => entrainment based estimation
  (more consistent with conv. modelling)

Identification of updraft source layer



Enhancement of Convective Parameterization Scheme

3h accumulated precipitation 1 Aug. 2014 03UTC



observation

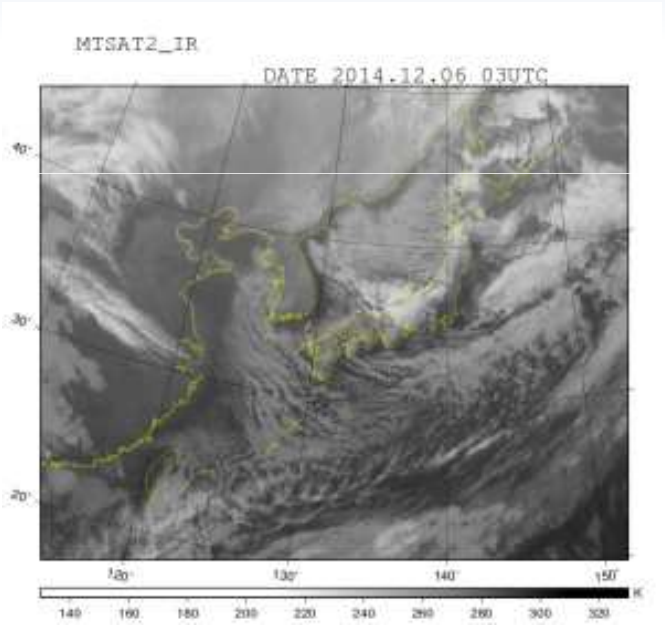
ASUCA with improved trigger function FT=24h

JMA-NHM (operational MSM) FT=24h

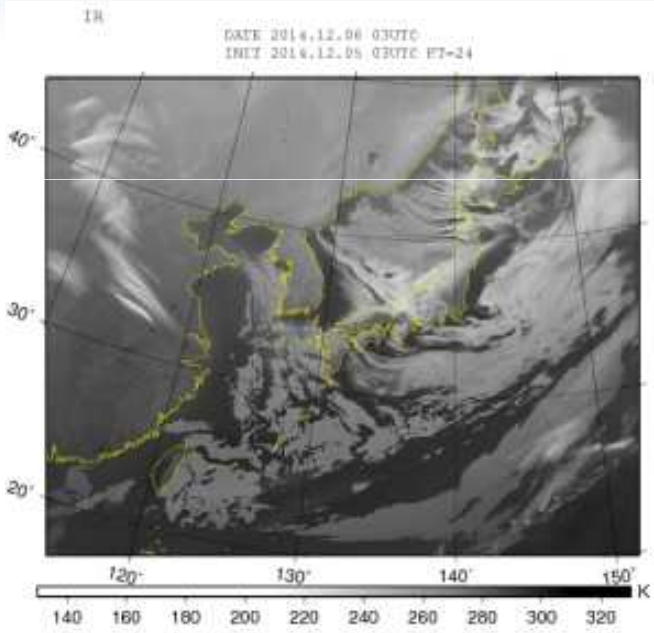
With the improved trigger function, convections over the sea are more consistent with observations.

Enhancement of Convective Parameterization Scheme

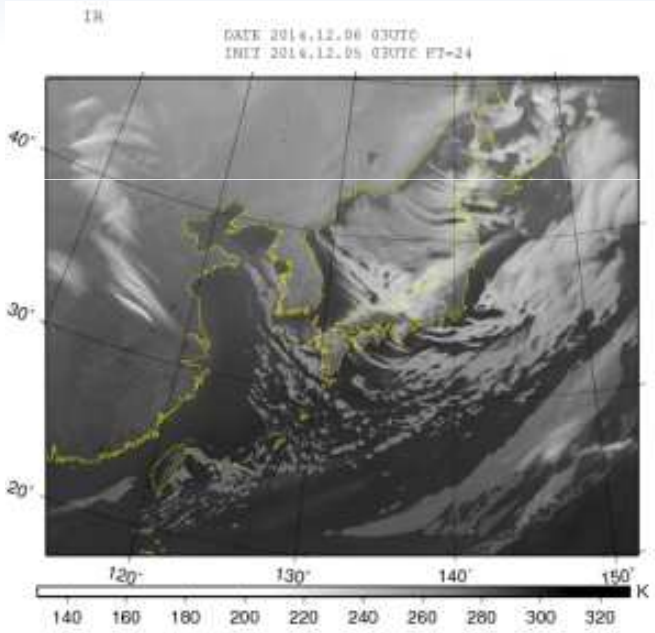
IR Satellite Imagery 06 Dec. 2014 03UTC



observation



ASUCA with improved trigger function FT=24h

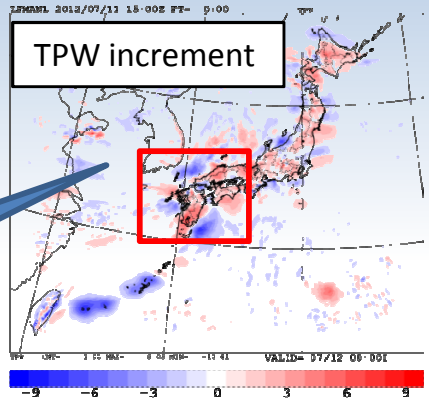


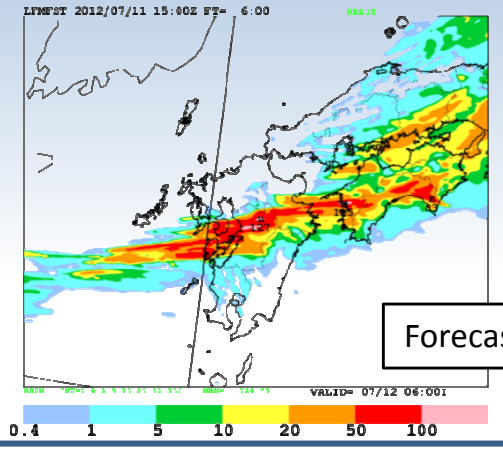
ASUCA Control FT=24h

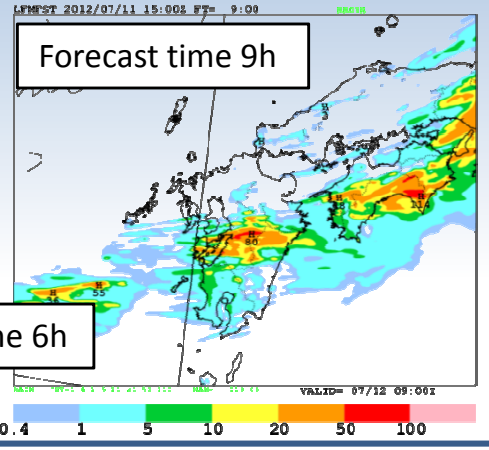
With the improved trigger function, convections over the sea are more consistent with observations.

Development of ASUCA-Var: Use of Ensemble Forecast in DA

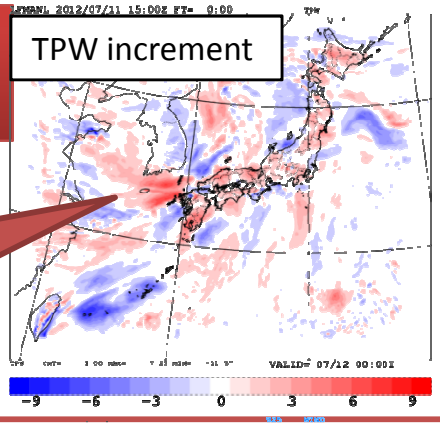
3D-Var

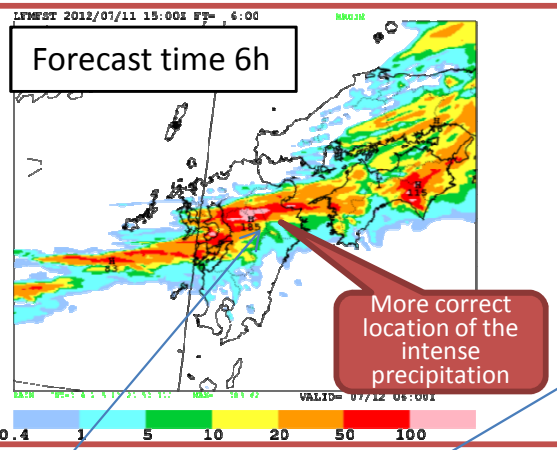


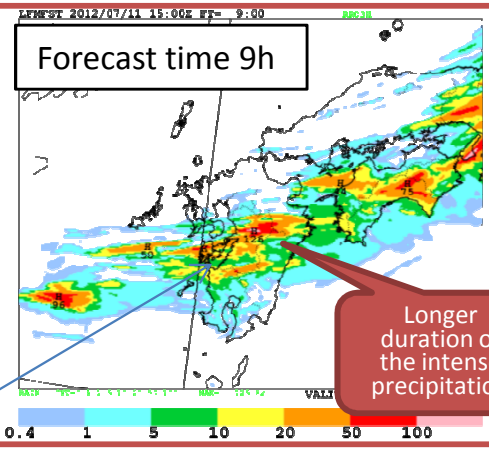




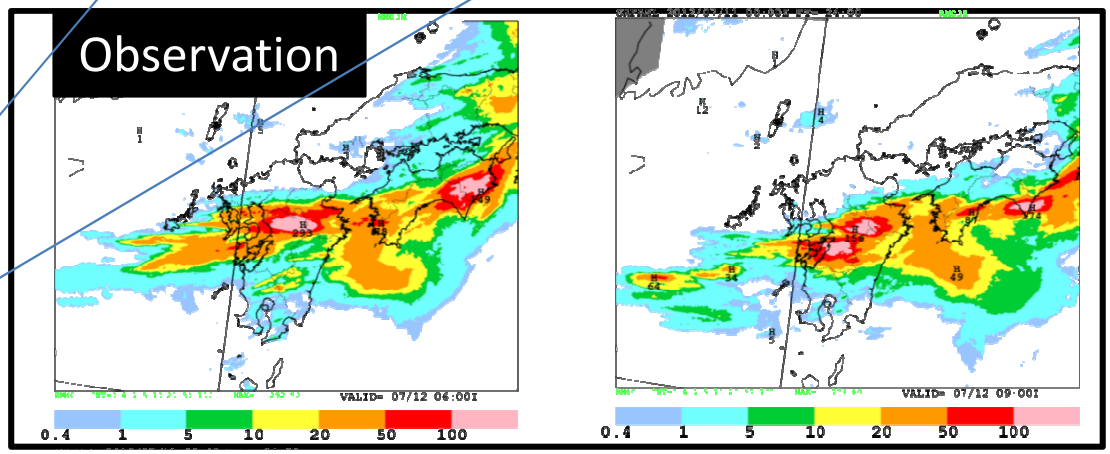
Hybrid 3D-EnVar
Bc=50%,Be=50%







Ensemble information
DA more consistent with the flow
=> forecast more consistent with the obs.
(eg. Shifting the front to the north to forecast a better location of the precipitation.
eg. extending TPW upstream to allow a longer duration of the intense rain.)



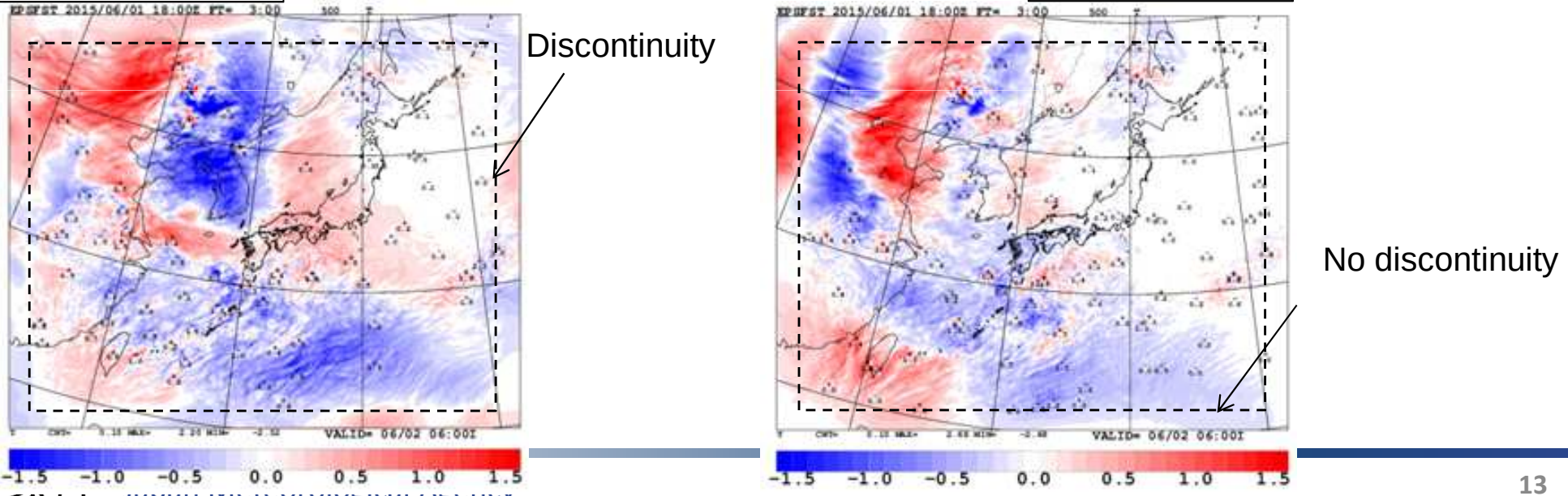
Development of MEPS: Improvement of LBC perturbations

For MEPS (5km, 11mem) , there is a need from forecasters to follow scenario from individual member.

Current perturbations
IC pert: GSV + MSV 40km + MSV 80km <=> LBC pert. : WEPS
=> former and latter stages of a MEPS perturbation forecast are not necessarily consistent.

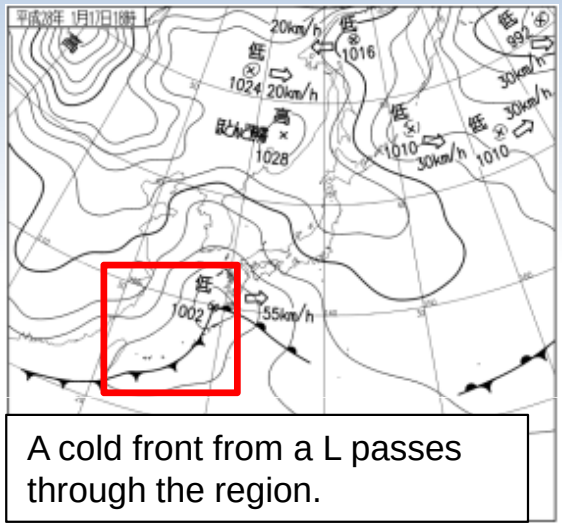
=> GSV (large scale part of the IC pert.) was tried as LBC pert.

Control SV+WEPS 850hPa EPT pert. INI: 1 Jun. 2016 18UTC FT=3h **Test SV+SV**



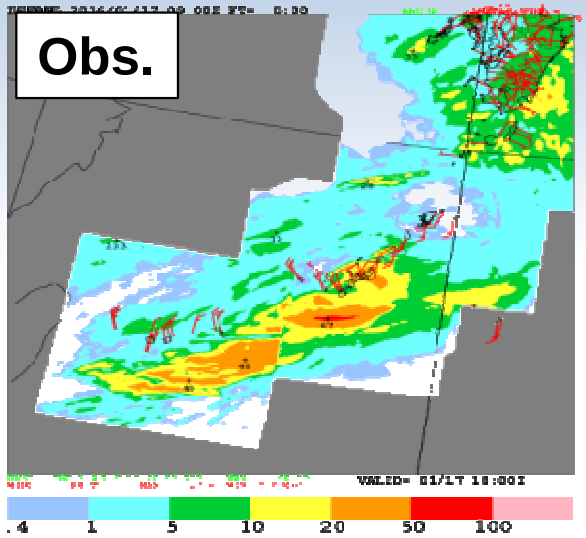
Development of MEPS: Improvement of LBC perturbations

Experiment shows enhanced consistency with the new LBC pert.

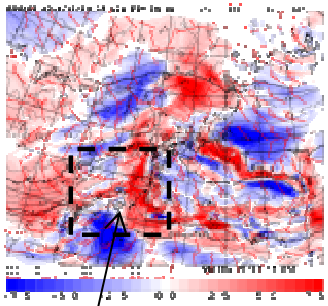


A cold front from a L passes through the region.

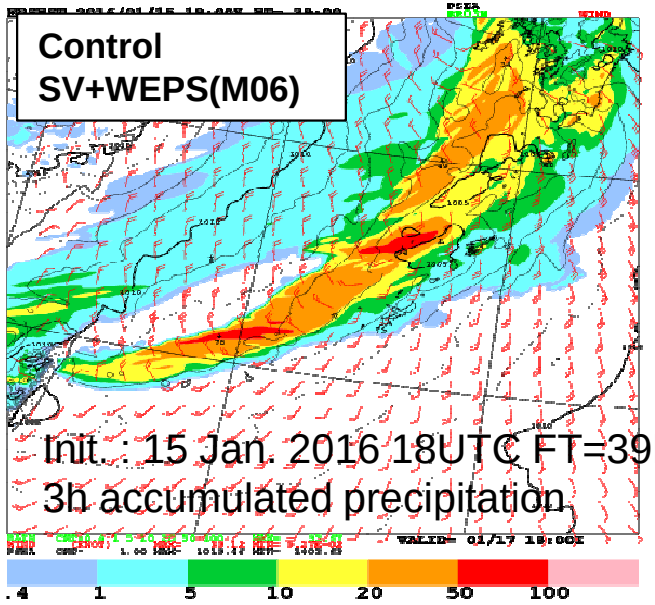
09UTC 17 Jan. 2016



850hPa EPT pert.



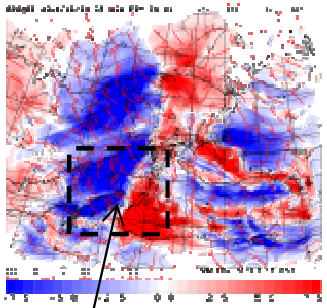
IC pert. intensifies but LBC pert. weakens the cold air flow



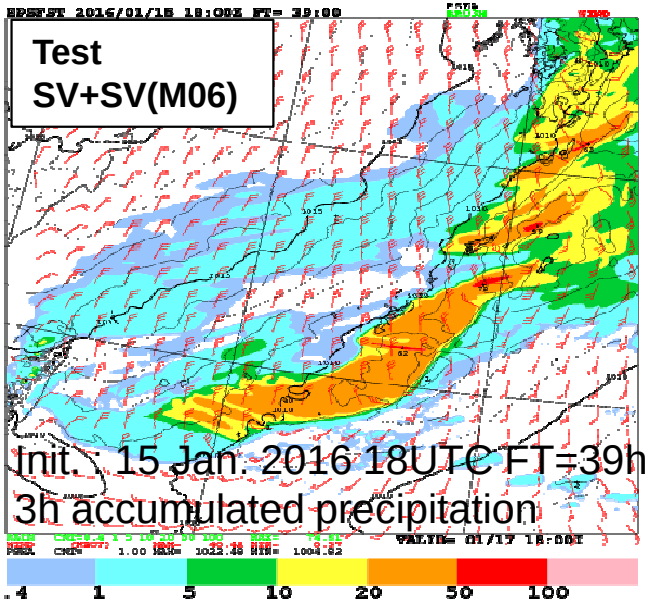
Init.: 15 Jan. 2016 18UTC FT=39h
3h accumulated precipitation

delays progress of the front.

850hPa EPT pert.



IC and LBC perturbations intensify the cold air flow



Init.: 15 Jan. 2016 18UTC FT=39h
3h accumulated precipitation

pushes the front forward.

Future plan

- On the current super computer system
  - Incorporation of ASUCA into MSM. L48 to L76 (in 2016-2017)
  - Incorporation of ASUCA-4DVar into MA (in 2017)
- On the next super computer system
  - Raising MSM model top height from about 22km to about 37km (5hPa)
  - Increasing vertical resolution of MSM from L76 to L96
  - Increasing vertical resolution of LFM from L58 to L76
  - Full operation of Meso-EPS
  - Hybrid data assimilation for MSM and LFM