Development of limited-area NWP systems at JMA

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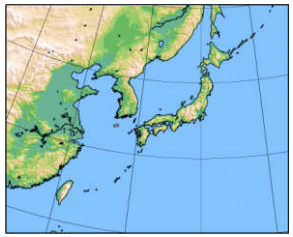
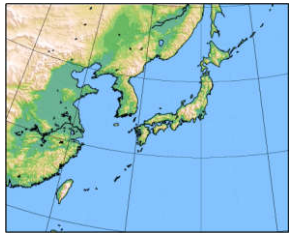
Current NWP models of NPD/JMA

	In Operation				Under Trial
	Global Spectral Model **GSM**	Meso-Scale Model **MSM**	Local Forecast Model **LFM**	Global Ensemble **GEPS**	Meso-scale Ensemble **MEPS**
objectives	Short- and Medium-range forecast	Disaster reduction Aviation forecast	Aviation forecast Disaster reduction	One-week forecast Typhoon forecast	
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	76 21.8km	58 20.2km	100 0.01 hPa	76 21.8km
Forecast Hours (Initial time)	132 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) 132 h (06, 18 UTC)* 27 members	39hours (00,06,12,18 UTC) 21 members
Initial Condition	Global Analysis (4D-Var)	Meso-scale Analysis (4D-Var)	Local Analysis (3D-Var)	Global Analysis with ensemble perturbations (SV, LETKF)	Meso-scale Analysis with ensemble perturbations (SV)

* when a TC of TS intensity or higher is present or expected in the RSMC Tokyo - Typhoon Center's area of responsibility (0º–60ºN, 100ºE–180º).

JMA 10th generation supercomputer system

JMA began the operation of its new supercomputer system on 5 June 2018.

Migration of operational NWP suites has successfully completed on schedule (~ 1 year).

Effective computer capacity (in terms of meteorological calculation) was enhanced about 10 times.

Comparison of Specifications

	Previous	New
Model	HITACHI SR16000/M1 (Vendor: Hitachi)	Cray XC50 (Vendor: Hitachi)
Theoretical Peak Performance	847 TFlops (*)	18,166 TFlops
Capacity of Main Memory	108 TBytes	528 TBytes
Capacity of Magnetic Disk	348 TBytes	10,608 TBytes

Future major upgrades of the limited-area NWP systems planned on the new supercomputer system

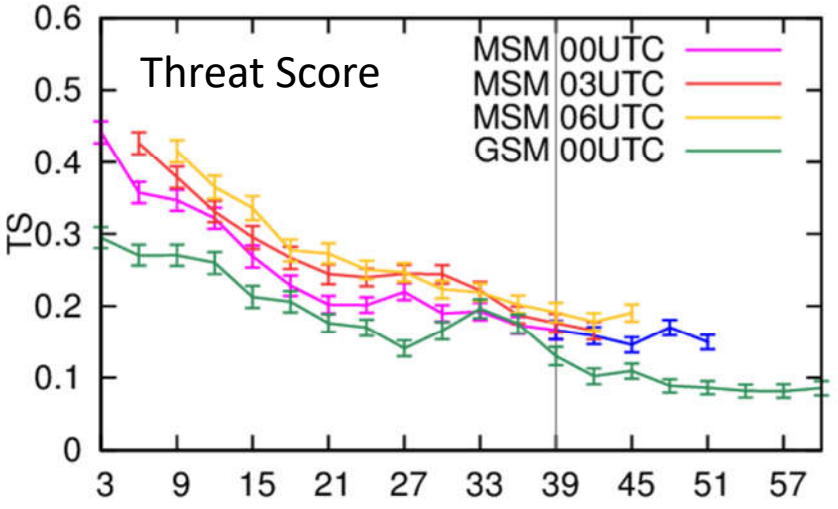
- Extension of forecast ranges of MSM and LFM
- Full operation of MEPS (21 members 4 runs/day, currently under trial)
- Incorporation of ASUCA-4DVar into MA
- Increasing vertical layers of LFM from L58 to L76
- Increasing vertical layers of MSM from L76 to L96
- Hybrid data assimilation for MSM and LFM

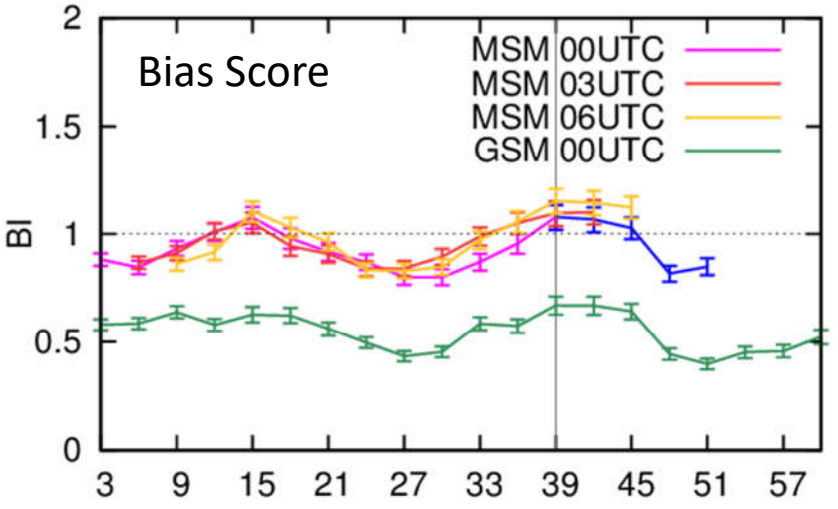
Extension of forecast range of MSM

- 39h => 51h in 00 and 12UTC runs (out of 8 runs/day)
- aimed at an enhanced support of weather forecasters
- Operation will start in 2019.

MSM gives precipitation forecasts better than those from the operational global spectral model (GSM) without drastic degradation in its performance over the extended range.

Threat Score and Bias Score of 3h accumulated precipitation
20km gauge, threshold 10mm/3h, 27 Jun. – 14 Jul.,13 Aug. – 30 Aug, 2016

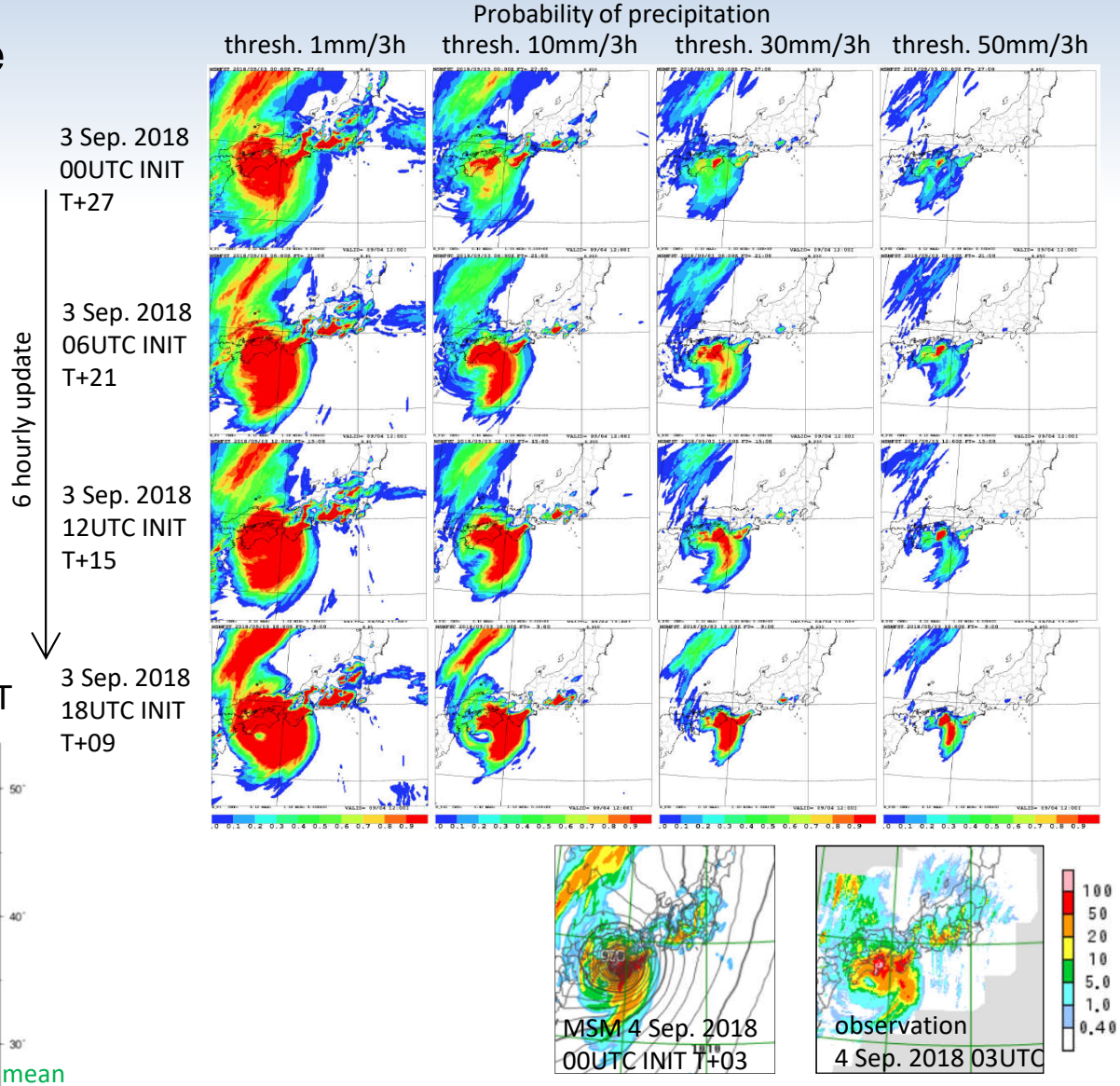




Enhancement of MEPS

- Development of MEPS, currently under trial, is in progress to provide uncertainty and probabilistic information of MSM.
- Full operation of MEPS is scheduled to start in 2019.
- Enhancement of MEPS was applied on 5 Jun. 2018.
  - ensemble size 11=>21
  - 1 run/day => 4 runs/day

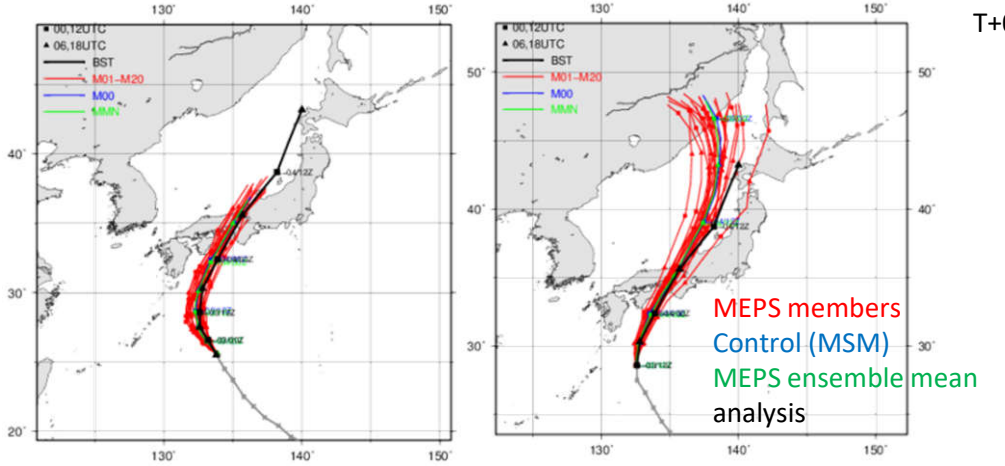
3h accumulated precipitation valid at 4 Sep. 2018 03UTC



Typhoon track forecasts

2 Sep. 2018 18UTC INIT

3 Sep. 2018 12UTC INIT



Smaller deviation from the analysis => smaller dispersion

Larger deviation from the analysis => larger dispersion

MEPS predicts regions of intense precipitation corresponding to the observations with gradually higher probabilities through updates of forecast. (The control run (MSM) gives a good forecast in this case.)

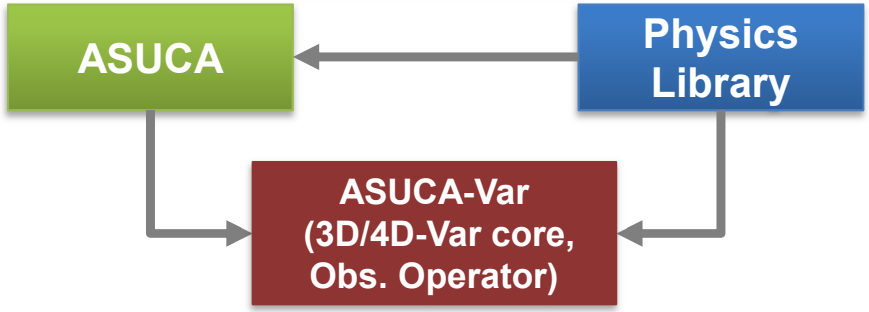
A New Non-Hydrostatic NWP Framework: ASUCA

JMA has been developing a new Forecast/DA system “ASUCA”.

ASUCA: a new non-hydrostatic dynamical core

Physics Library: a repository of highly-portable physical process routines

ASUCA-Var: a 3D/4D-Var data assimilation system based on ASUCA



- Operational implementation of ASUCA-based systems
  - Jan. 2015 LFM JMA-NHM => ASUCA
    LA JNoVA 3D-Var => ASUCA-3DVar
  - Feb. 2017 MSM JMA-NHM => ASUCA
  - Jul. 2017 real-time monitoring analysis (Hourly Analysis)
    JNoVA 3D-Var => ASUCA-3DVar
  - Jul. 2017 MEPS JMA-NHM => ASUCA
- Development in progress
  - ASUCA-4DVar for MA
  - ASUCA-SV for MEPS

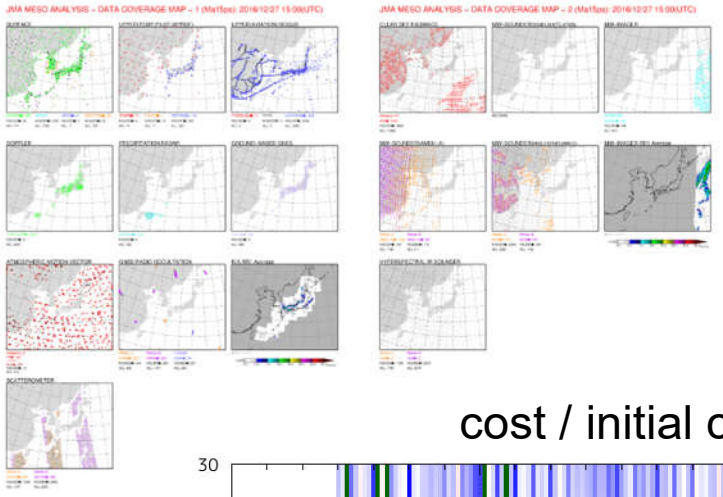
Development of ASUCA-4DVar

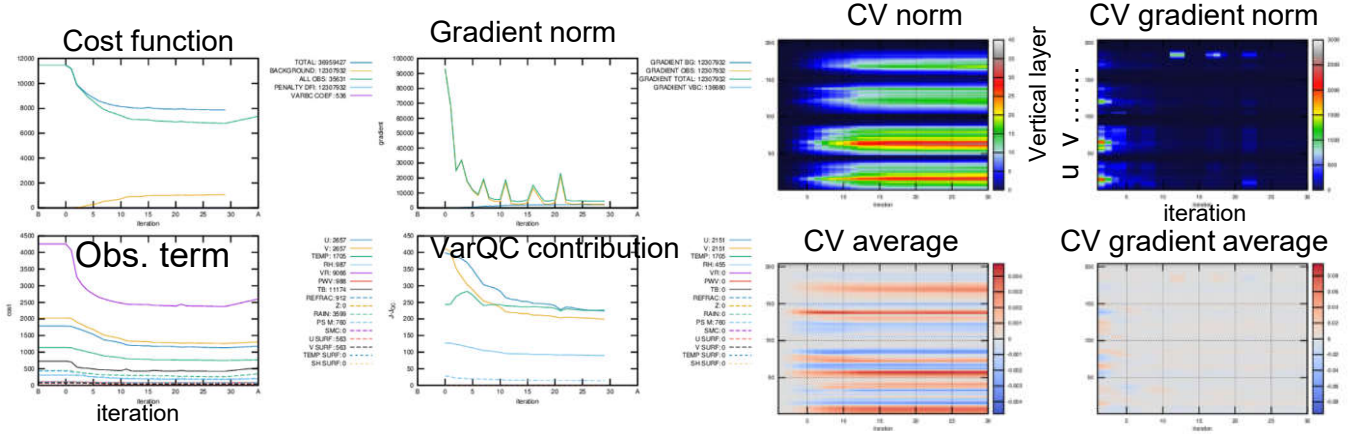
ASUCA-4DVar

- Development is in progress for the next DA system of the operational MA.
- TL/AD based on ASUCA.
- Current status: close systematic examinations and updates to enhance robustness and stability in operational situation.

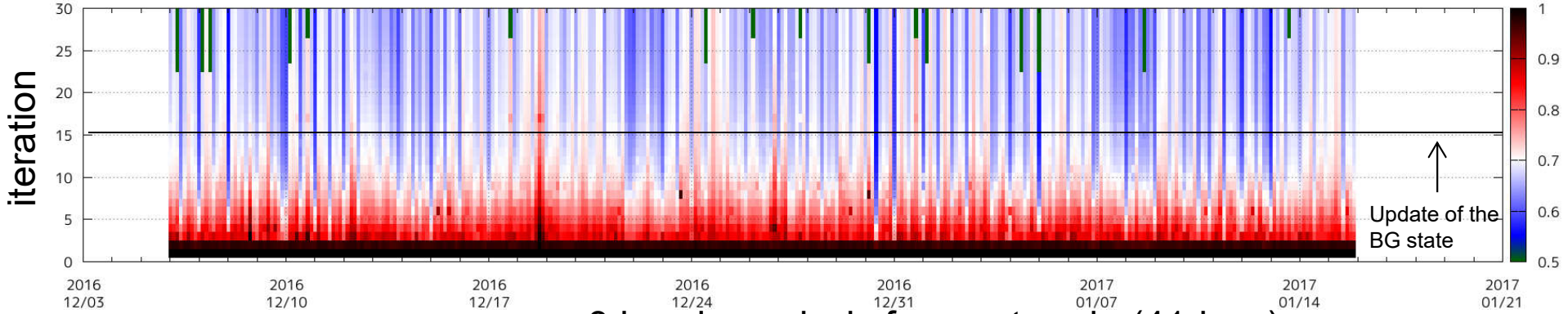
Example of ASUCA-4DVar run

Observation coverage map





cost / initial cost through the analysis-forecast cycle



3 hourly analysis forecast cycle (41days)

Development of ASUCA-SV

Development of ASUCA-SV, using TL/AD based on ASUCA, is in progress for an upgrade of MEPS initial perturbations.

Example of perturbation from ASUCA-SV

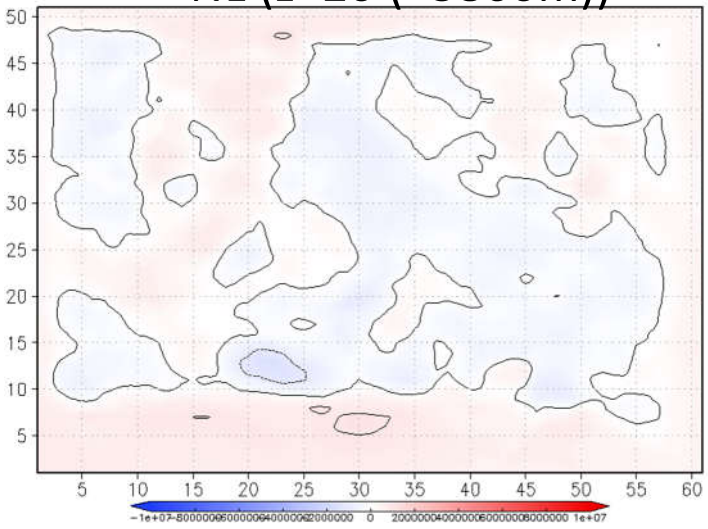
The leading SV calculated from the Lanczos algorithm with 4 iterations using a kinetic energy norm

Singular Value	NL growth rate	TL growth rate
5.1972	5.1815	5.1972

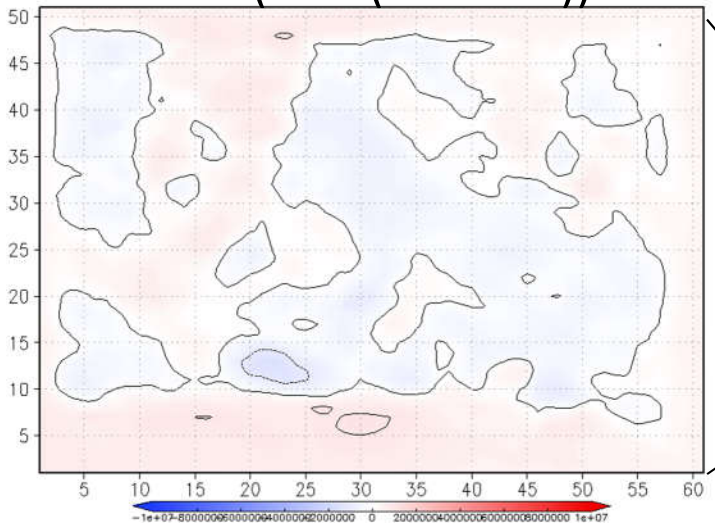
Singular value well coincides with NL and TL growth rates.

X-momentum perturbation

NL (z=20 (~3860m))



TL (z=20(~3860m))



dx=5km, 61x51x48
optimization time
interval 50 minutes

NL and TL time evolutions show a similar pattern.

Development of Hybrid DA

Development of a hybrid 4D-Var system is in progress, for future enhancement of MA.

Flow dependent background error from ensemble forecasts.

The hybrid 4D-Var with an extension of control variables including hydrometeors and TL/AD of cloud-microphysics scheme enables direct assimilation of radar reflectivity data.

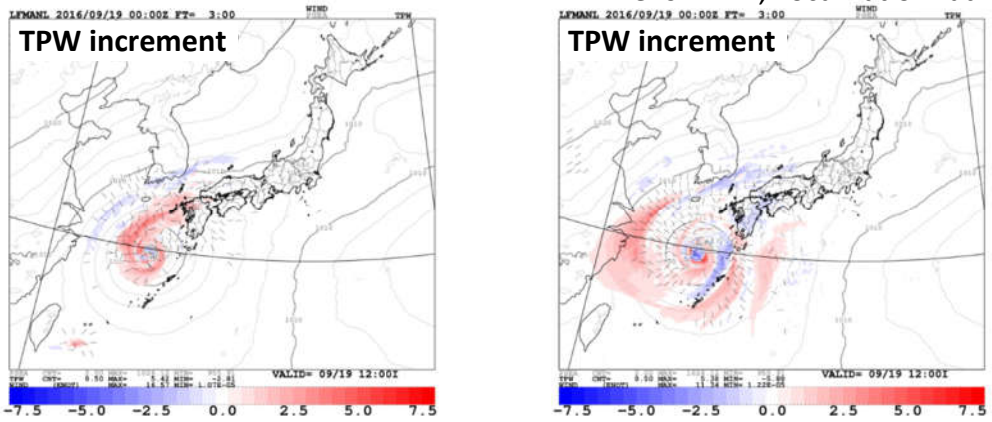
Traditional DA

Climatological(100%)+Ensemble(0%)

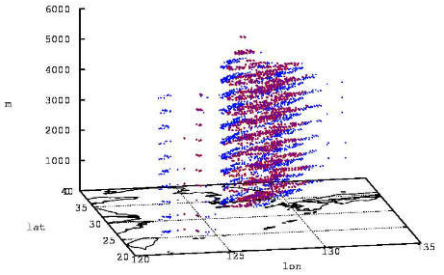
Hybrid DA

Climatological(50%)+Ensemble(50%)

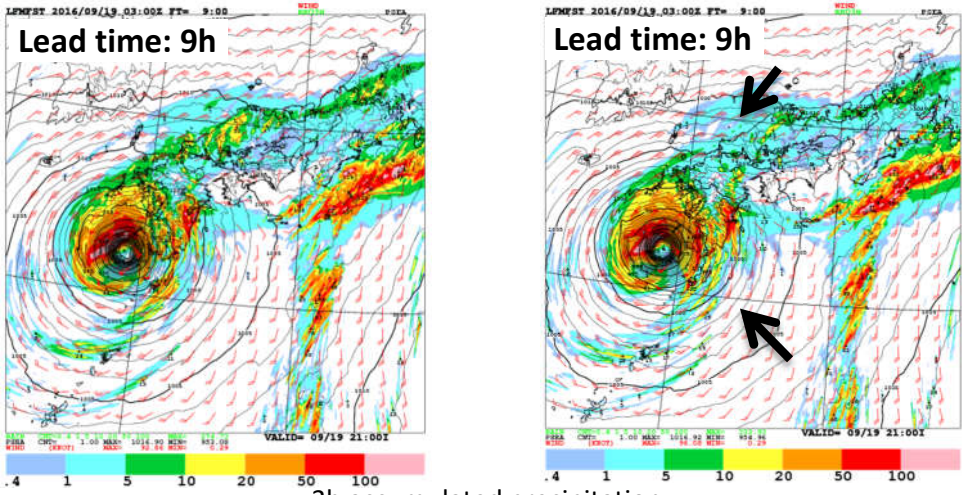
Nens=12+1, Localization radius 300 km.



Color shade: Total Precipitable Water, Barbs: Surface Wind

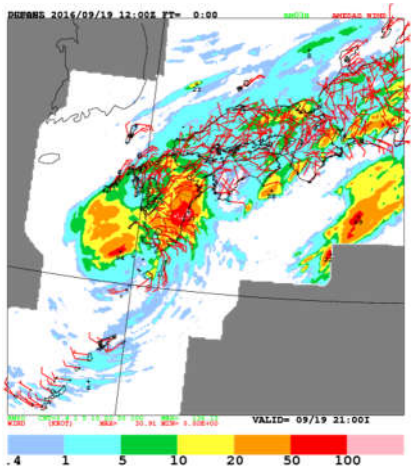


The experiment uses space-borne radar reflectivity data from GPM/DPR by JAXA.



3h accumulated precipitation

Observation



Improvement in precipitation forecast.