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Development of Limited-Area NWP Systems at JMA

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Recent works

- Local Forecast Model (LFM, $\Delta x = 2$ km)
 - Forecast model ASUCA incorporated into operation in January 2015
- Meso-Scale Model (MSM, $\Delta x = 5$ km)
 - Forecast model ASUCA incorporated into operation in February 2017
 - 4D-Var data assimilation still based on previous model
- Meso-Scale Ensemble Prediction System (MEPS, $\Delta x = 5$ km, 21 members)
 - Incorporated into operation in June 2019

Overview

Operational suites of NWP systems at JMA

	Global Spectral Model (GSM)	Meso-Scale Model (MSM)	Local Forecast Model (LFM)	Global Ensemble Prediction System (GEPS) ¹	Meso-Scale Ensemble Prediction System (MEPS)
Objectives	Short- and medium-range forecasts	Disaster reduction, aviation forecasts, short-range forecasts	Aviation forecasts, disaster reduction	Typhoon forecasts, one-week forecasts	Disaster reduction, aviation forecasts
Forecast domain	Global 	Japan and its surroundings 	Japan and its surroundings 	Global 	Japan and its surroundings 
Horizontal resolution	TL959 (≈ 20 km)	5 km	2 km	TL479 (≈ 40 km)	5 km
Vertical levels / top	100 / 0.01 hPa	76 / 21.8 km	58 / 20.2 km	100 / 0.01 hPa	76 / 21.8 km
Forecast hours (initial times)	264 hours (12 UTC), 132 hours (00, 06, 18 UTC)	51 hours (00, 12 UTC), 39 hours (03, 06, 09, 15, 18, 21 UTC)	10 hours (00–23 UTC hourly)	264 hours (00, 12 UTC), 132 hours (06, 18 UTC) ²	39 hours (00, 06, 12, 18 UTC)
Initial conditions	Global analysis (4D-Var)	Meso-scale analysis (4D-Var)	Local analysis (3D-Var)	Global analysis (4D-Var) with ensemble perturbations (SV, LETKF)	Meso-scale analysis with ensemble perturbations (SV)
Ensemble members	—	—	—	27	21 (Control = MSM)

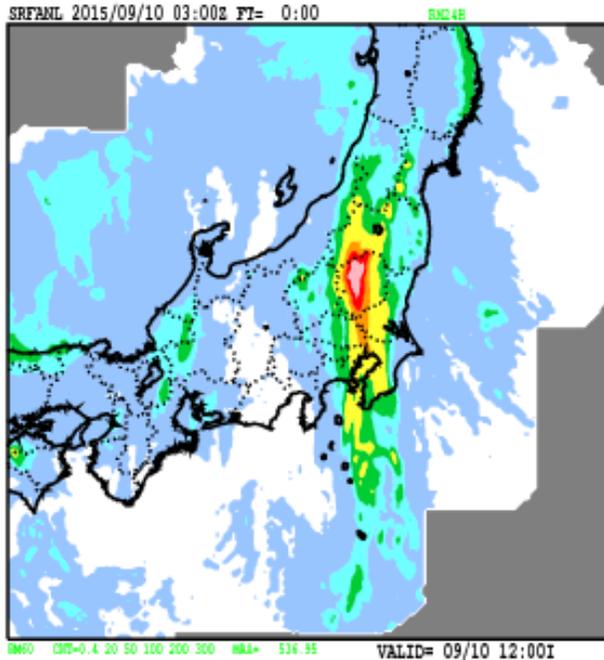
¹ Only the specifications of typhoon forecasts and one-week forecasts

² Only when a TC of TS intensity or higher is present or expected in the RSMC Tokyo–Typhoon Center’s area of responsibility (0°–60°N, 100°E–180°)

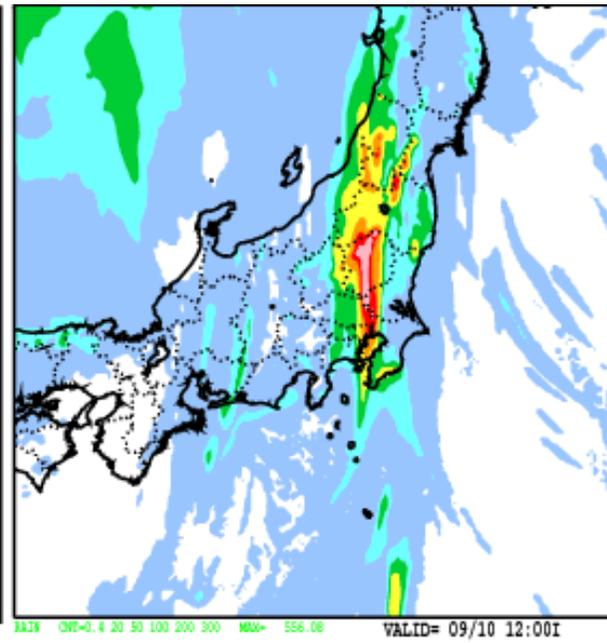
MSM and GSM

24-hour precipitation

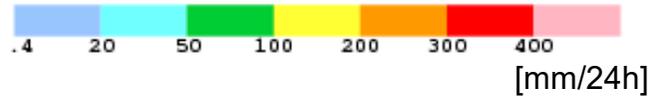
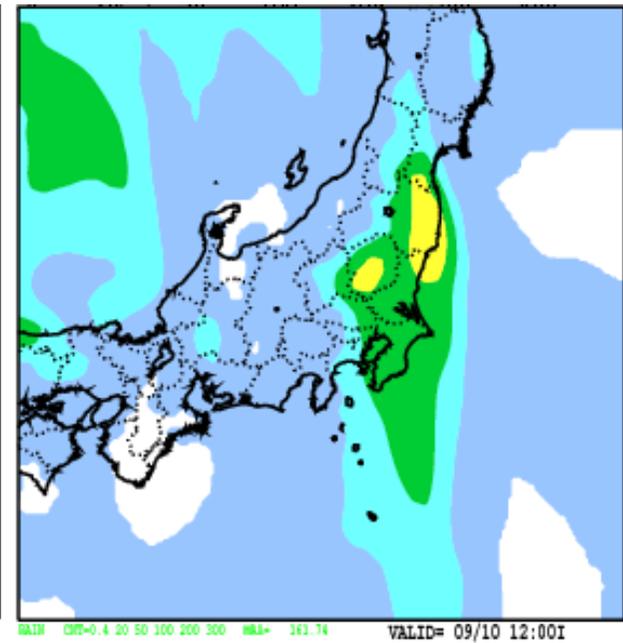
Radar/Raingauge-
Analyzed Precipitation



Operational MSM



Operational GSM



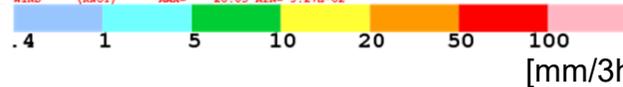
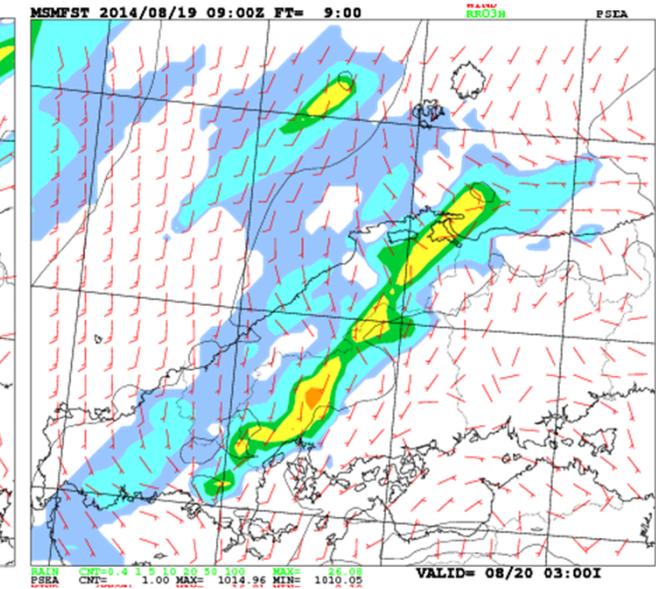
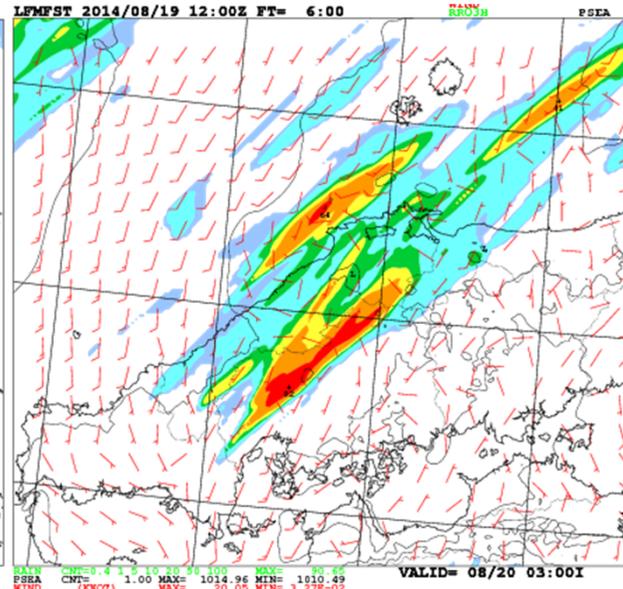
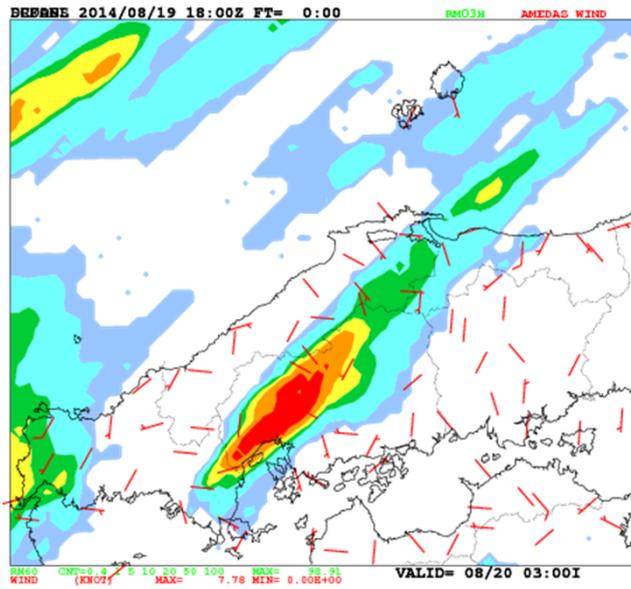
LFM and MSM

3-hour precipitation

Radar/Raingauge-
Analyzed Precipitation

Operational LFM

Operational MSM



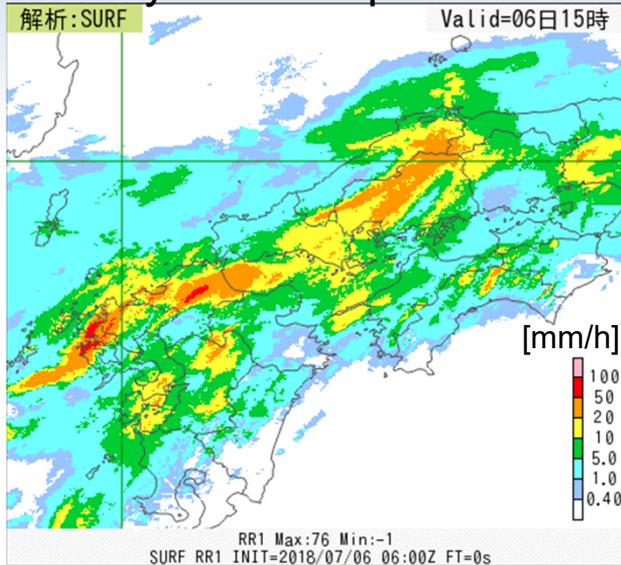
Convective initiation scheme
+ Cloud microphysics scheme

Convective parameterization
+ Cloud microphysics scheme

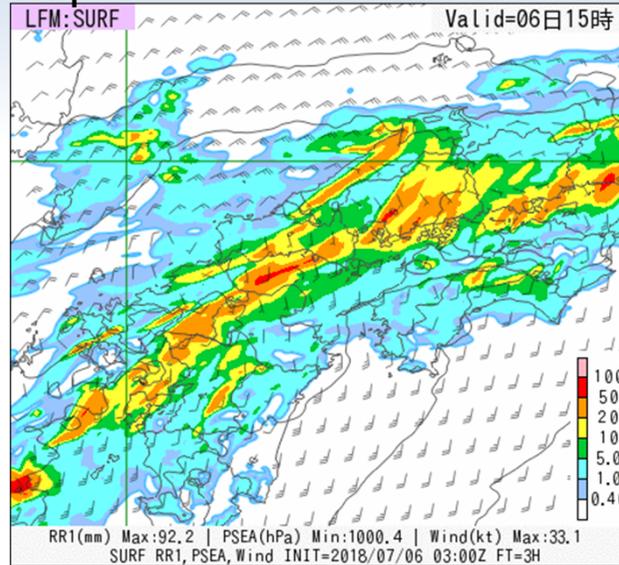
Representation of heavy rain

LFM and MSM

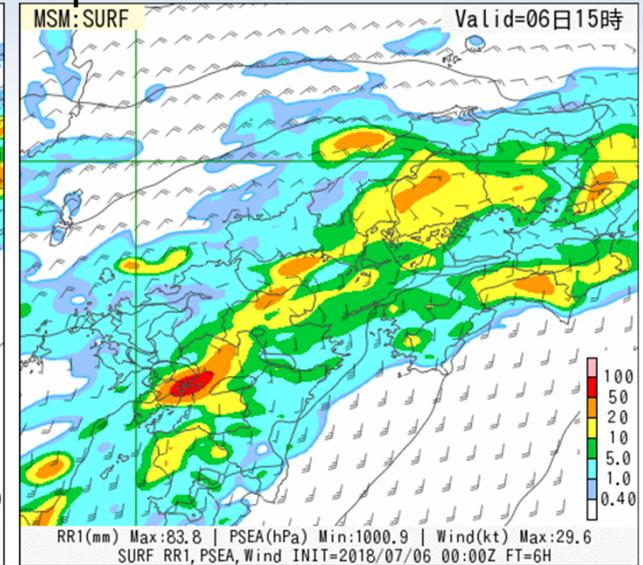
Radar/Raingauge-
Analyzed Precipitation



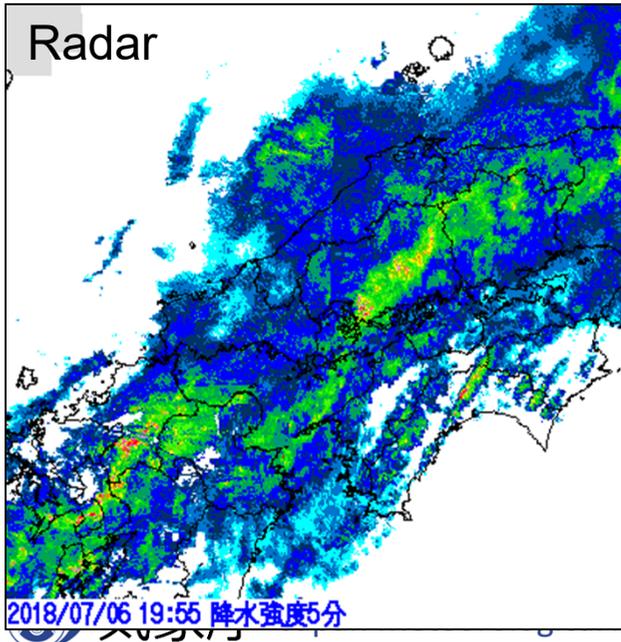
Operational LFM



Operational MSM



1-hour precipitation

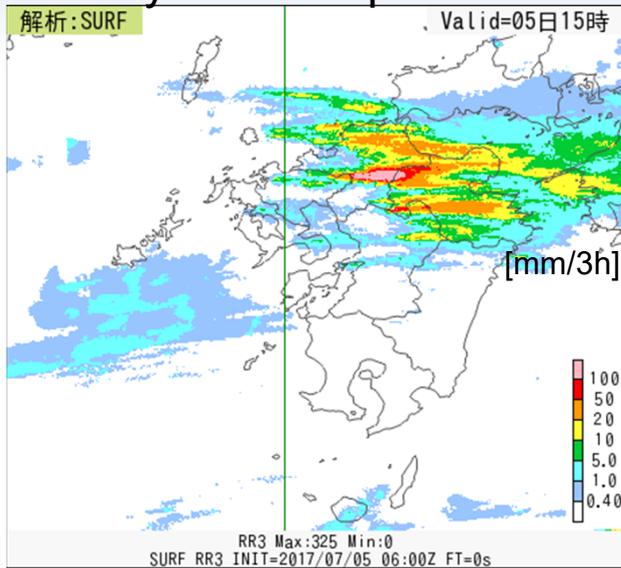


5-minute precipitation intensity

Representation of heavy rain

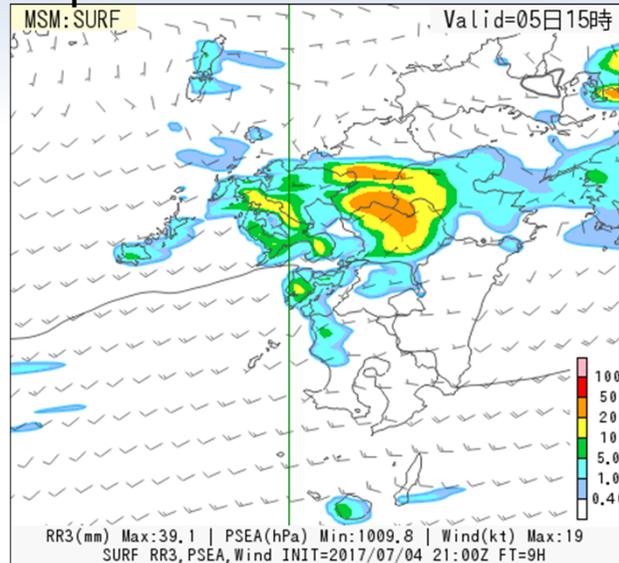
Impact of convective parameterization (CP)

Radar/Raingauge-
Analyzed Precipitation

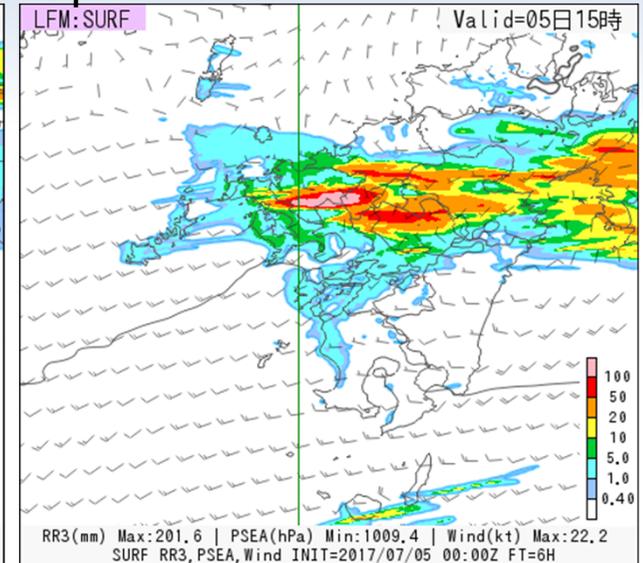


3-hour precipitation

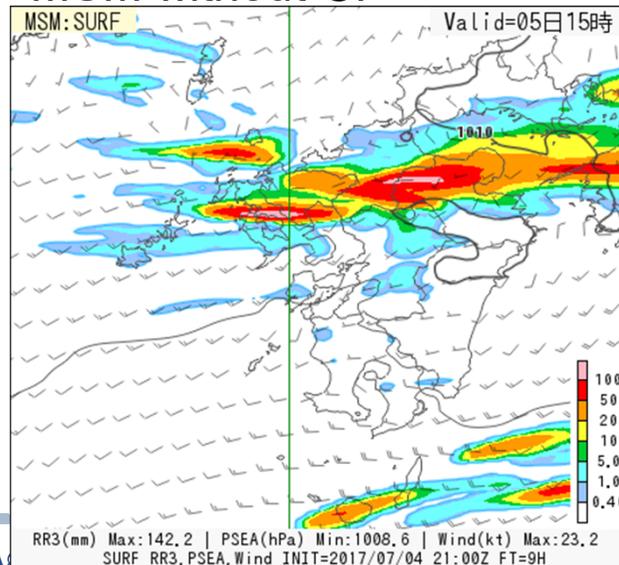
Operational MSM with CP



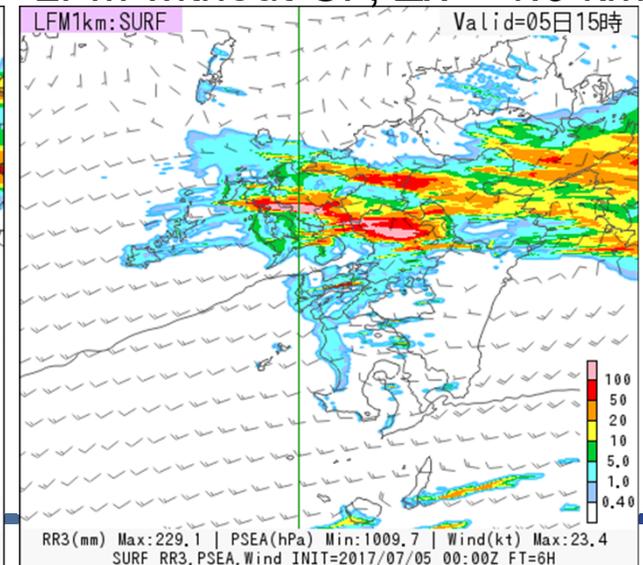
Operational LFM without CP



MSM without CP



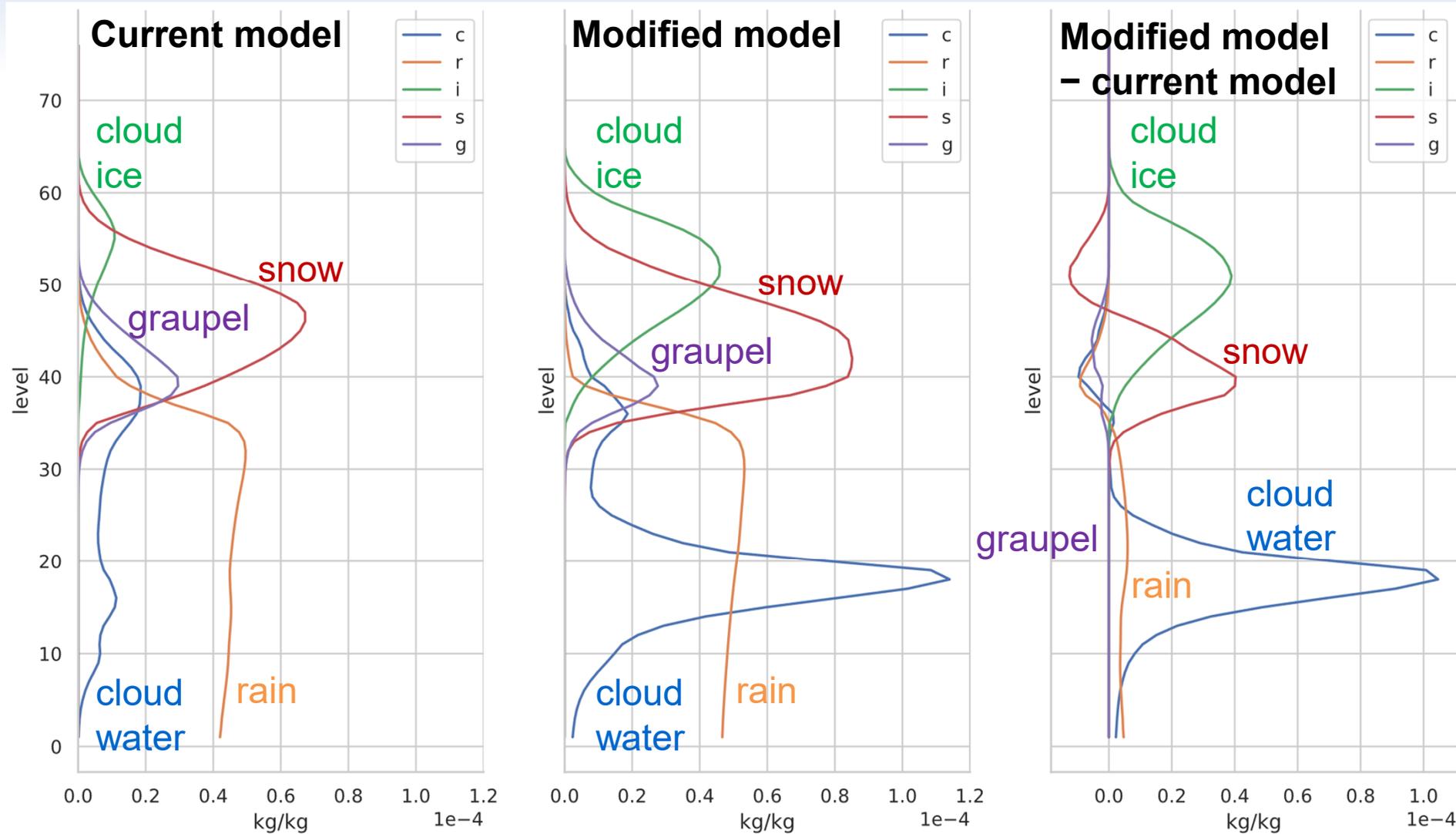
LFM without CP, $\Delta x = 1.0$ km



Modifications in cloud microphysics scheme

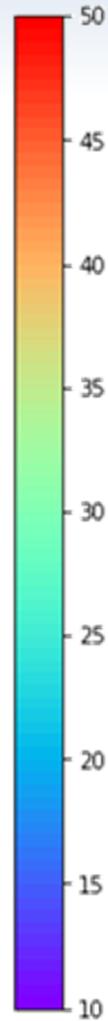
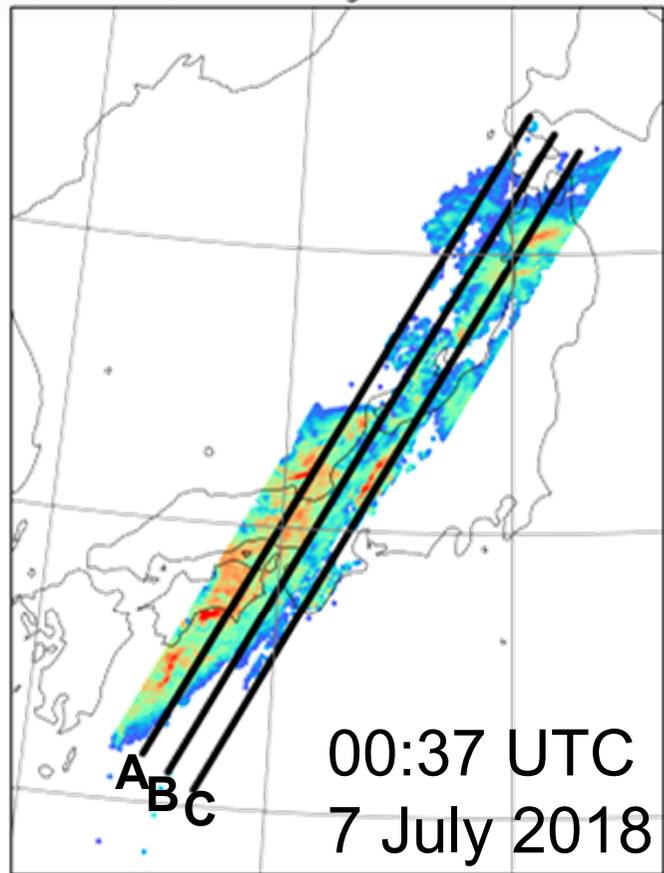
- Increased threshold value in Kessler autoconversion from cloud water into rain
- Modified particle size distributions of rain
- Adjusted terminal velocity of cloud ice

Vertical profile of mixing ratios

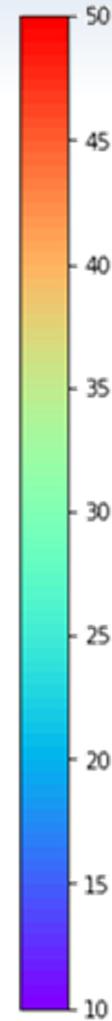
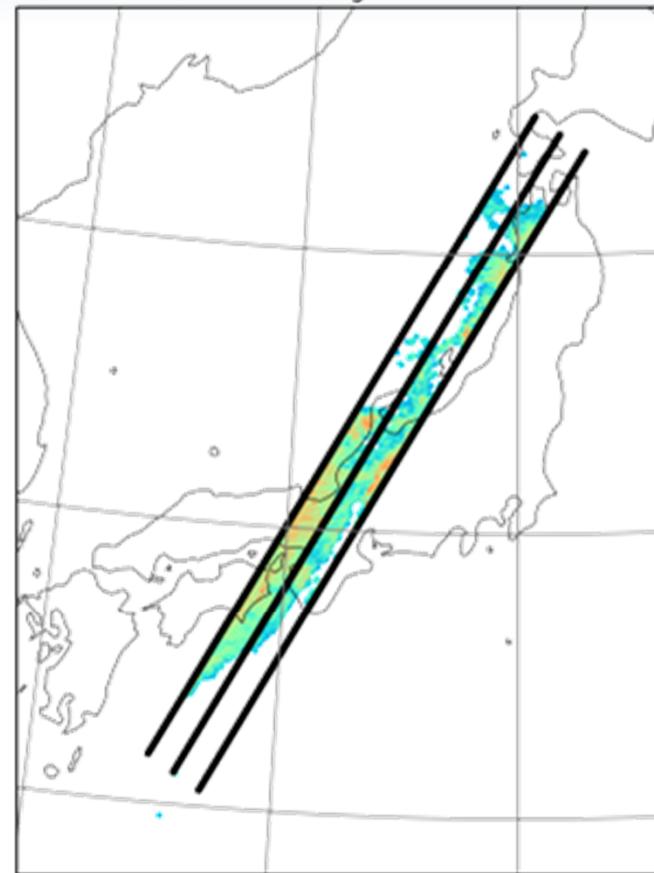


GPM Dual-frequency precipitation radar

Ku-band Precipitation Radar (KuPR) KuPR range=160



Ka-band precipitation radar (KaPR) KaPR range=160



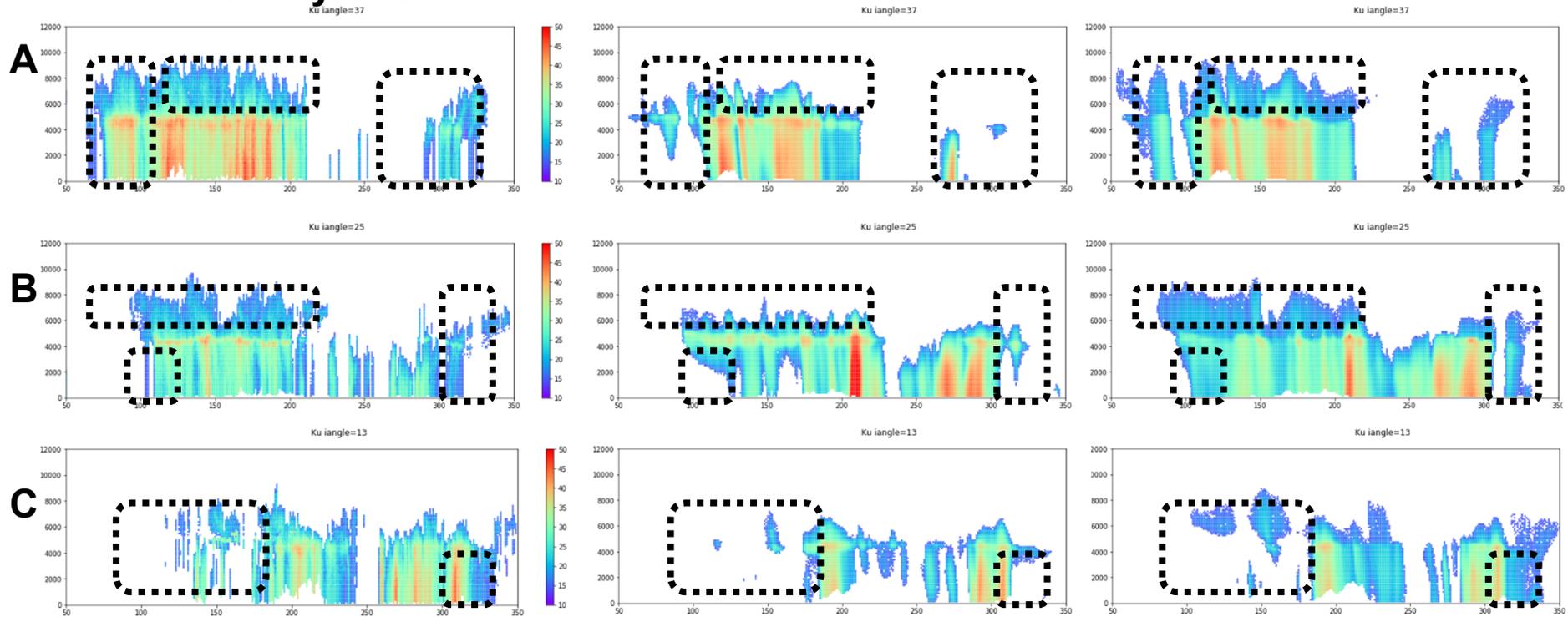
Impact of modifications

Vertical profiles of simulated KuPR reflectivity from MSM outputs

KuPR reflectivity observation

Current model

Modified model



Comparison with GPM Microwave Imager

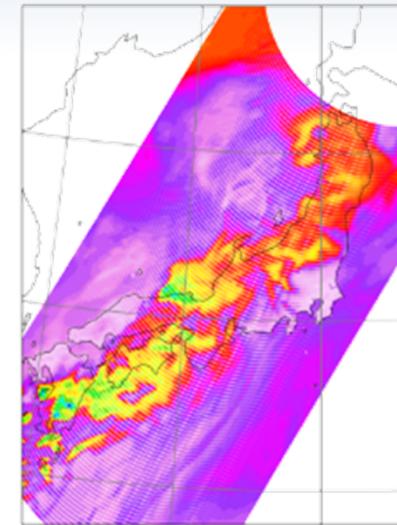
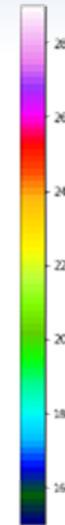
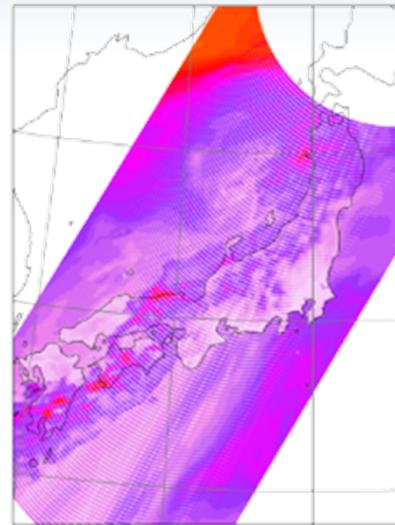
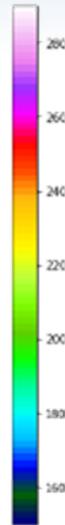
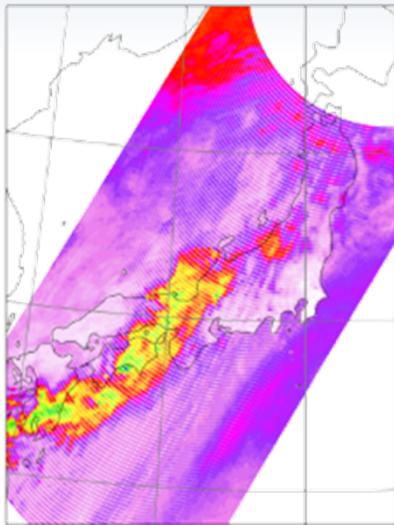
Simulated images from MSM outputs

Observation

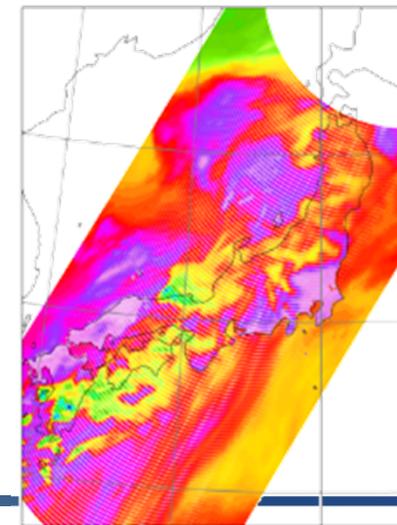
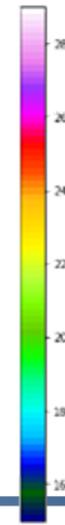
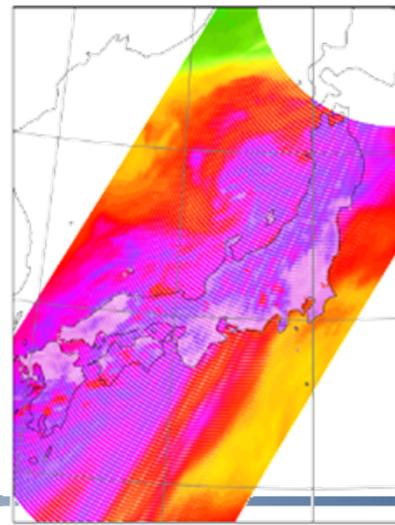
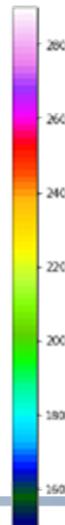
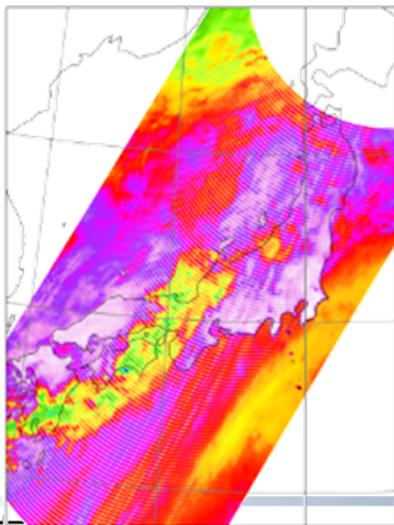
Current model

Modified model

GMI
89.00V

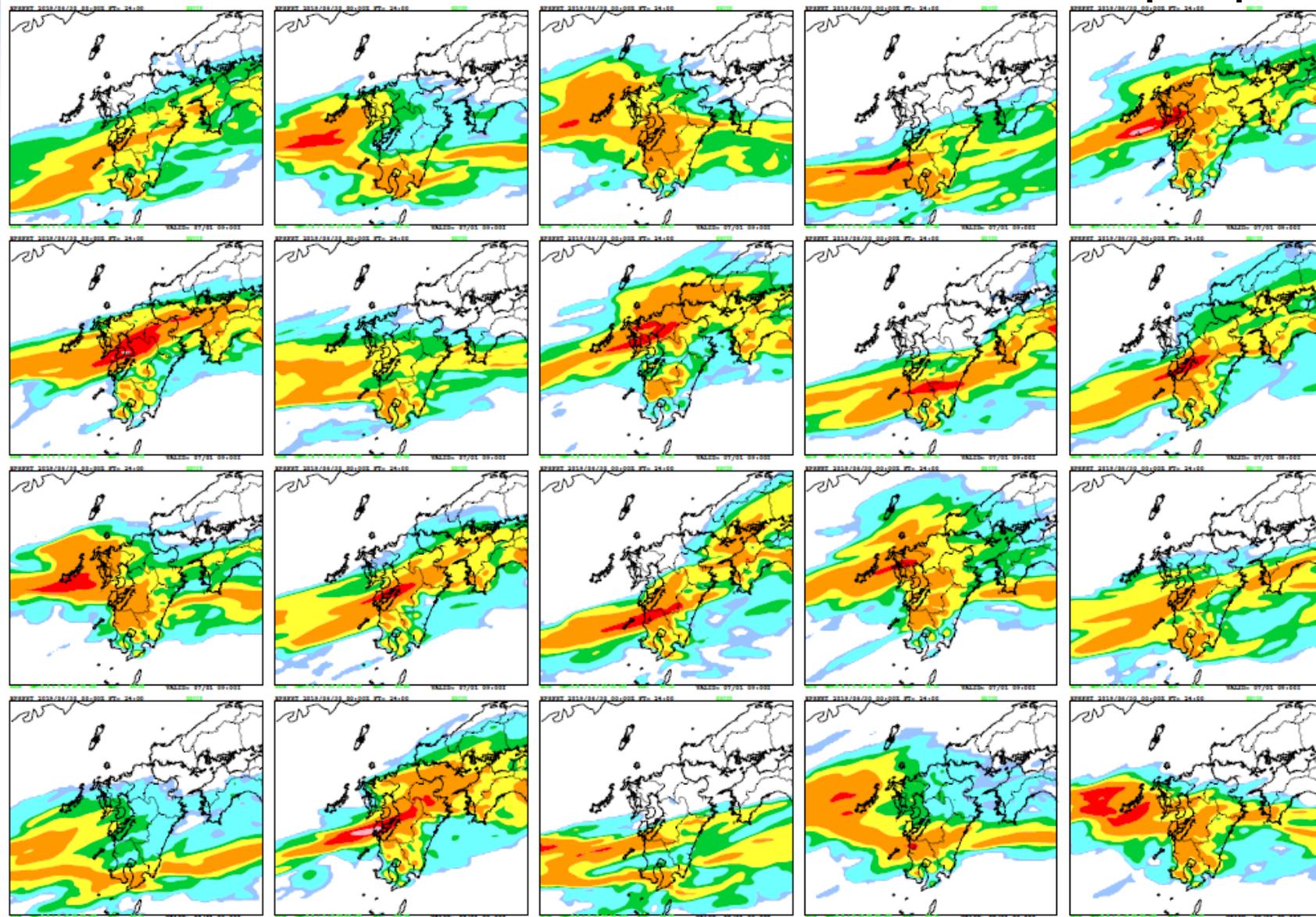


GMI
89.00H



Perturbed runs

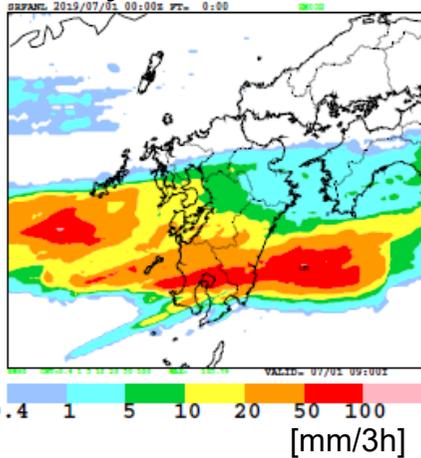
3-hour precipitation



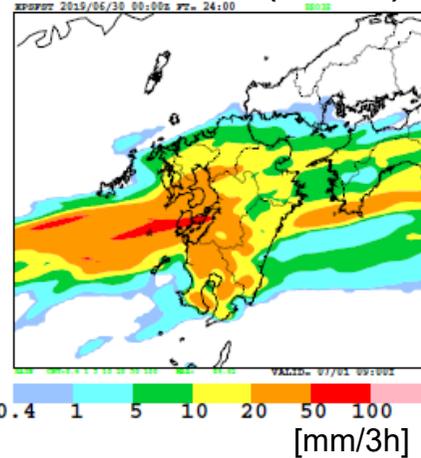
Control run, max, min, probabilities

3-hour precipitation

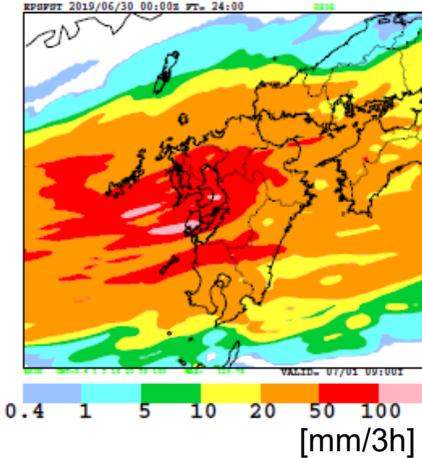
Analyzed rain



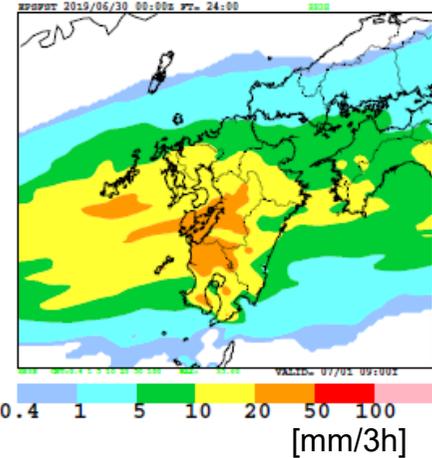
Control run (MSM)



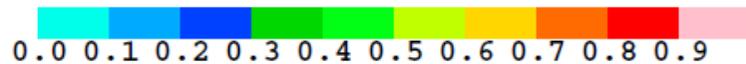
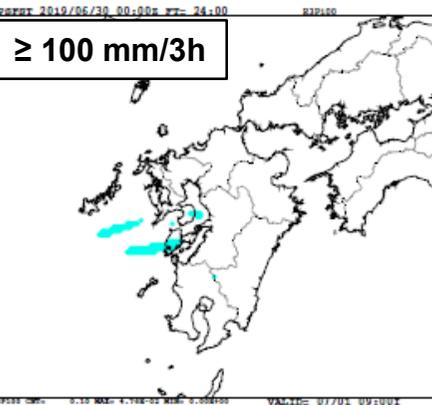
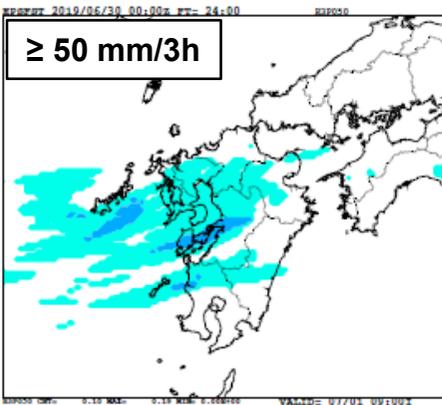
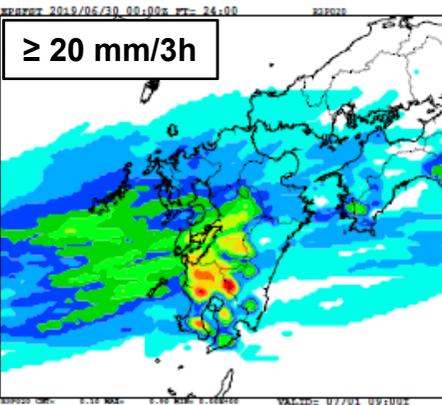
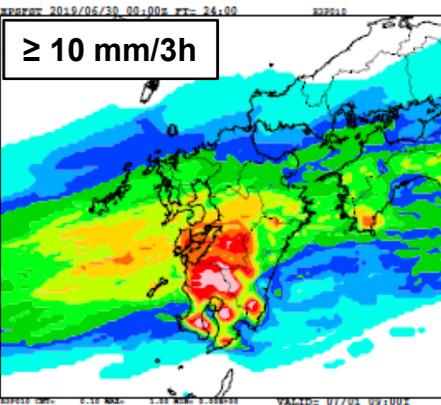
Maximum member



Minimum member

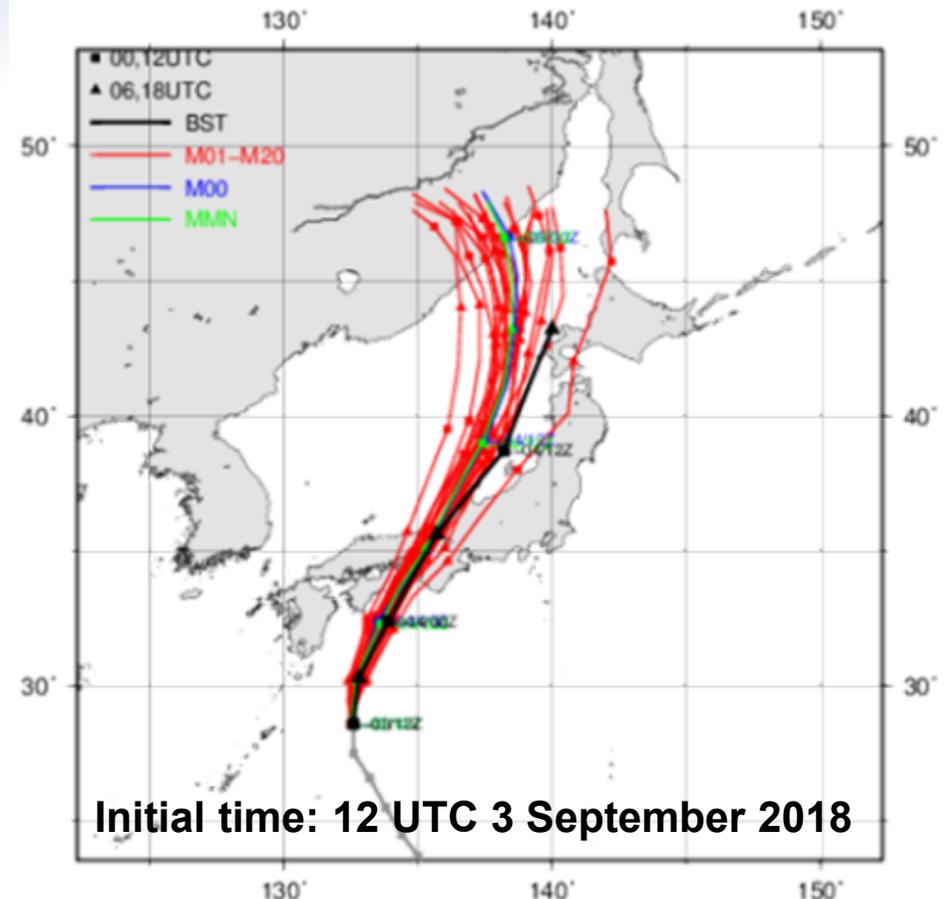
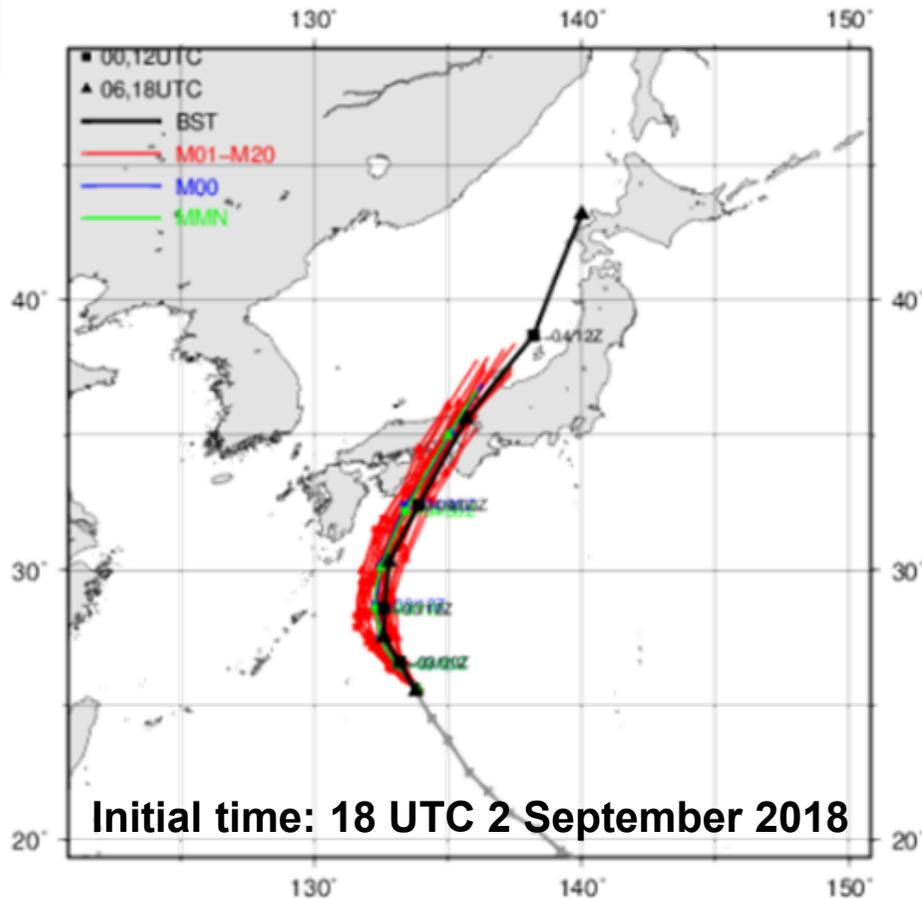


Probabilities with precipitation amount \geq thresholds



Typhoon track prediction

T1821



MEPS member ———
Control run (MSM) ———

MEPS ensemble mean ———
Best track ———

Future plans

- Improvements in physics schemes of MSM and MEPS in March 2020
- Incorporation of ASUCA-4DVar into MSM in March 2020
- Increasing vertical layers of MSM and LFM
- Incorporation of hybrid data assimilation into MSM and LFM
- Incorporation of ASUCA-SV into MEPS