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Development of Limited-Area NWP Systems at JMA

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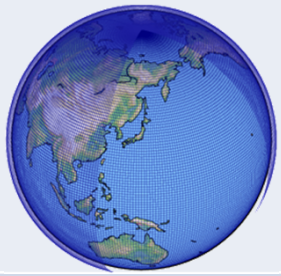
Operational suites of NWP systems at JMA

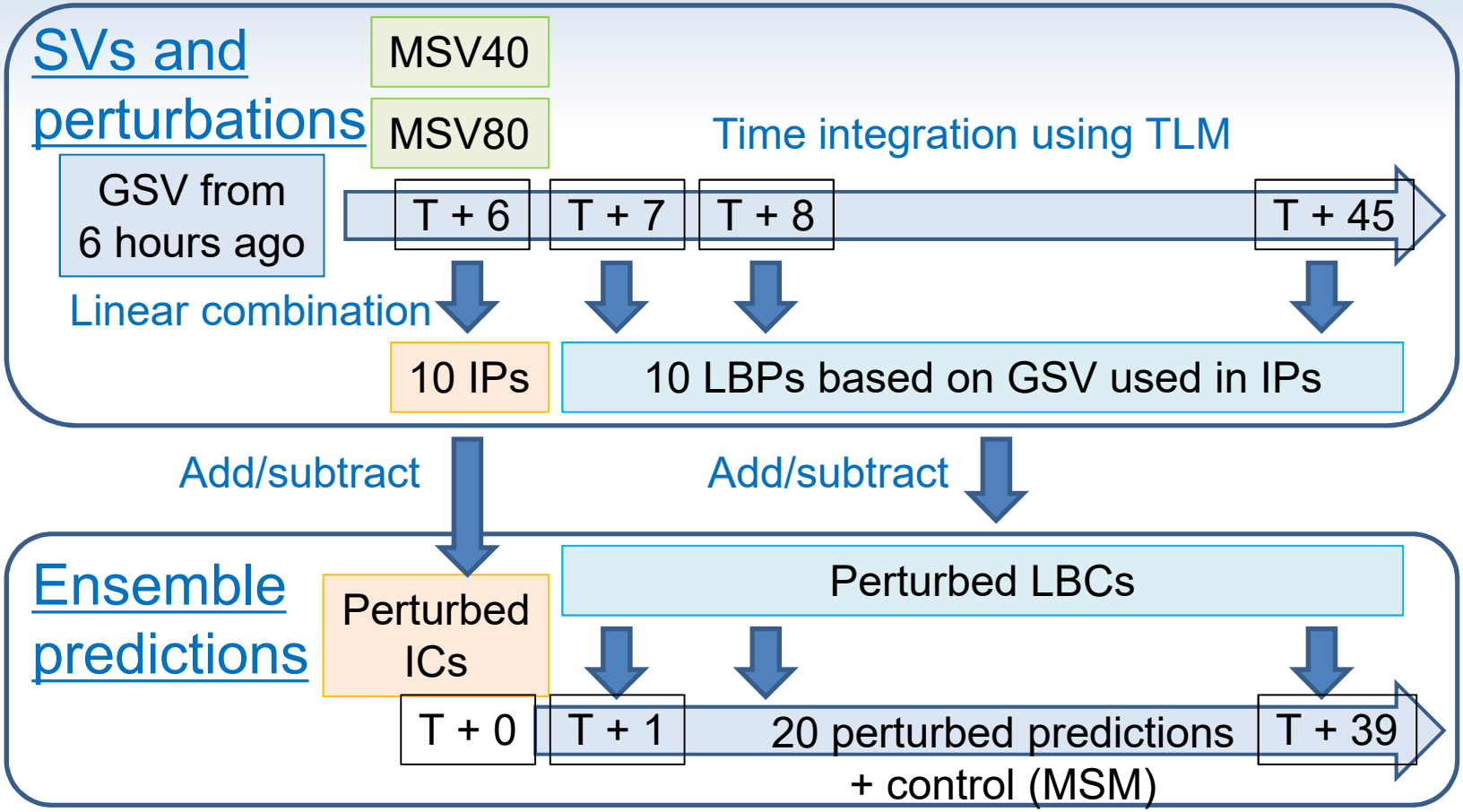
	Global Spectral Model (GSM)	Meso-Scale Model (MSM)	Local Forecast Model (LFM)	Global Ensemble Prediction System (GEPS)[1]	Meso-Scale Ensemble Prediction System (MEPS)
Objectives	Short- and medium-range forecasts	Disaster reduction, aviation forecasts, short-range forecasts	Aviation forecasts, disaster 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 (Hybrid 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 (0º–60ºN, 100ºE–180º)

Activities

- Local Forecast Model (LFM)
  - Enhancing vertical layers from 58 to 76 and improving physics schemes in March 2021
- Meso-Scale Model (MSM)
  - Upgraded 4D-Var data assimilation based on the new forecast model ASUCA and improved dynamics and physics schemes in March 2020 (Ikuta et al. 2020)
- Meso-Scale Ensemble Prediction System (MEPS)
  - Operation since June 2019 (MEPS1906, Ono et al. 2020)
  - Improved initial and lateral boundary perturbations in September 2020 (MEPS2009, this talk)

Perturbations and predictions



SV: singular vector
GSV: global SV, dx ≈ 270 km, optimization time interval = 45 h
MSV: mesoscale SV
MSV40: MSV, dx = 40 km, optimization time interval = 6 h
MSV80: MSV, dx = 80 km, optimization time interval = 15 h

TLM: tangent linear model
IP: initial perturbation
IC: initial condition
LBP: lateral boundary perturbation
LBC: lateral boundary condition

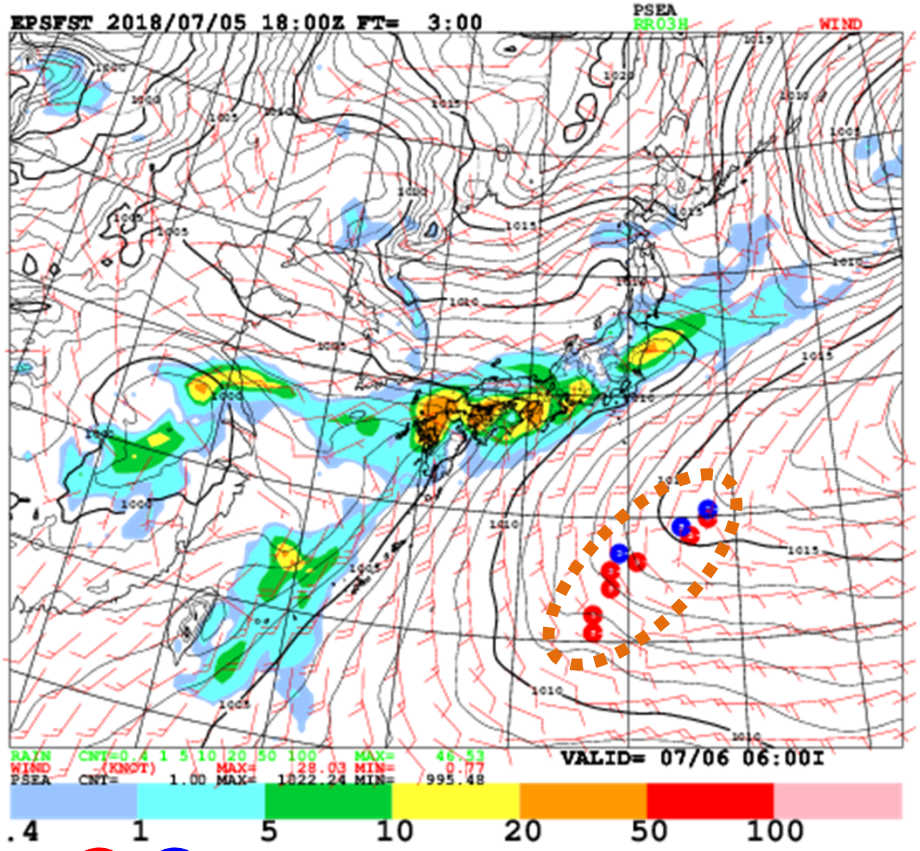
Modifications in MEPS2009

- IPs
  - Included adaptive target area for MSV
  - Adjusted upper limit of moisture perturbation amplitude for MSV
- LBPs
  - Changed target area for GSV
  - Adjusted weight for temperature term in total energy norm for GSV
  - etc.

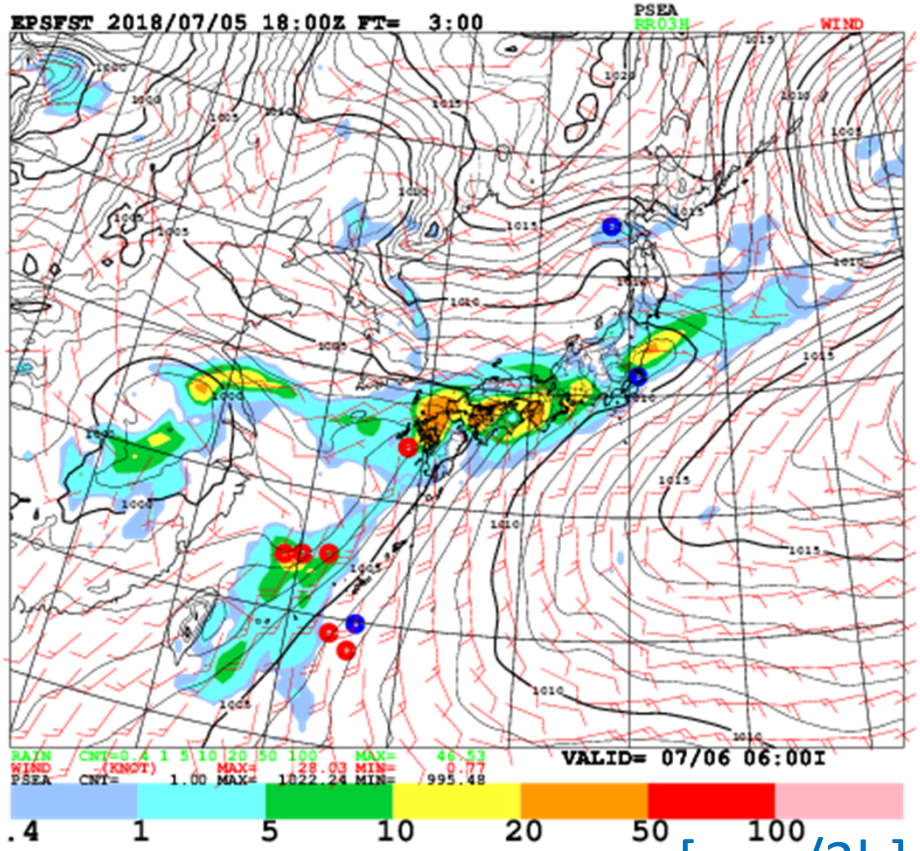
Adaptive target area for MSV

- Excluded areas where VOR925 < threshold in MEPS2009

MEPS1906



MEPS2009

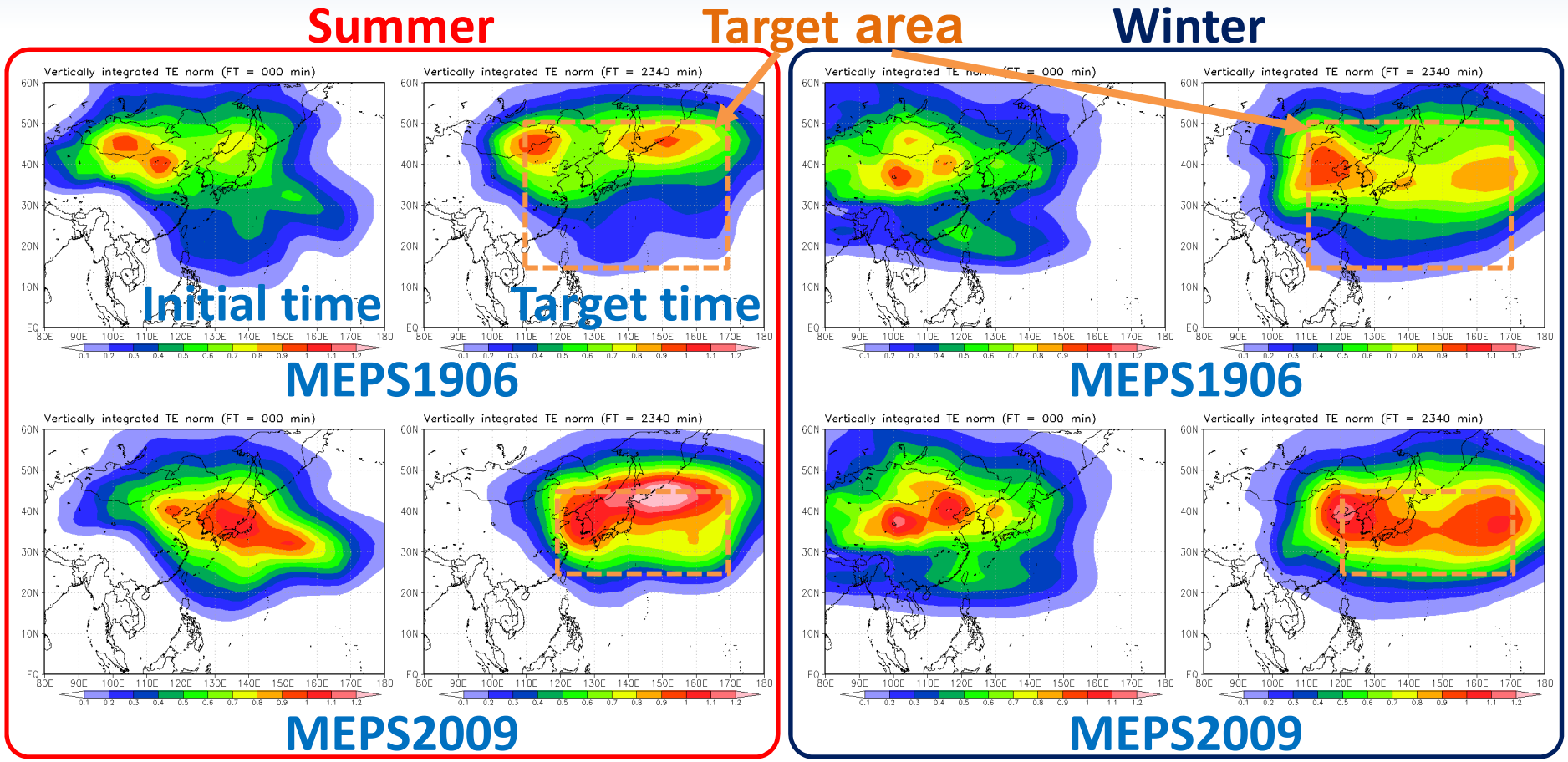


[mm/3h]

: Positions of peak in total energy norm,
colors: 3-h accumulated rain, barbs: wind, contours: PSEA

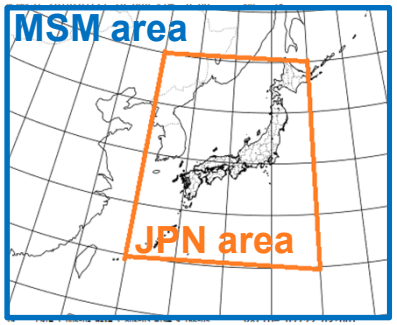
Changed target area for GSV

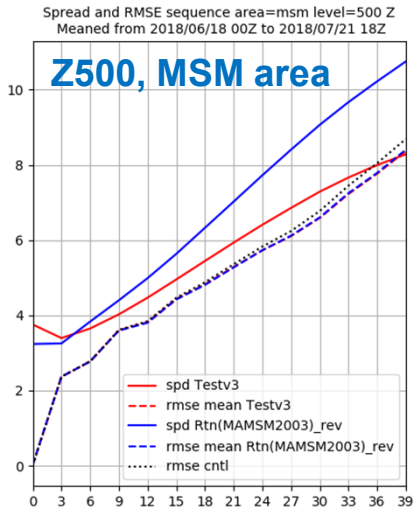
- MEPS1906 (110–170E, 15–50N) → MEPS2009 (120–170E, 25–45N)

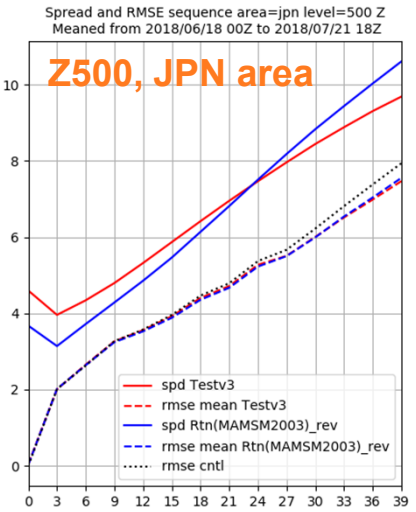


Vertically integrated total energy norm

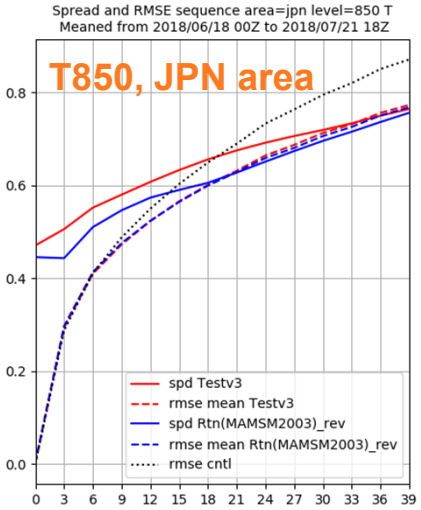
Ensemble spread (summer)

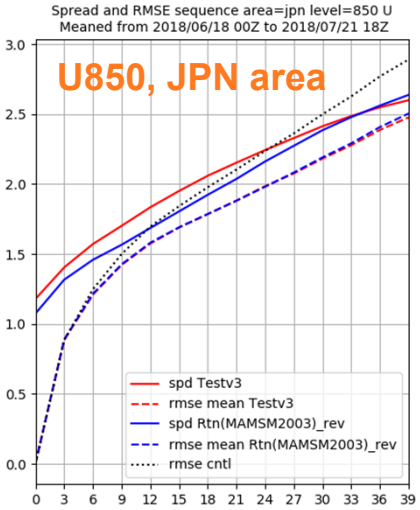


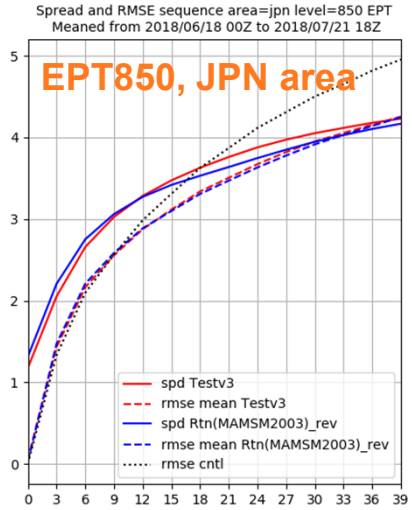




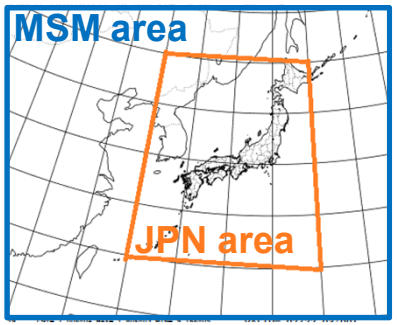
spread, MEPS2009
spread, MEPS1906
RMS error, MEPS2009
RMS error, MEPS1906

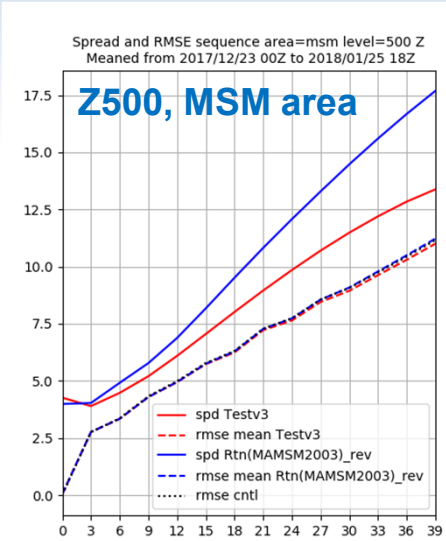


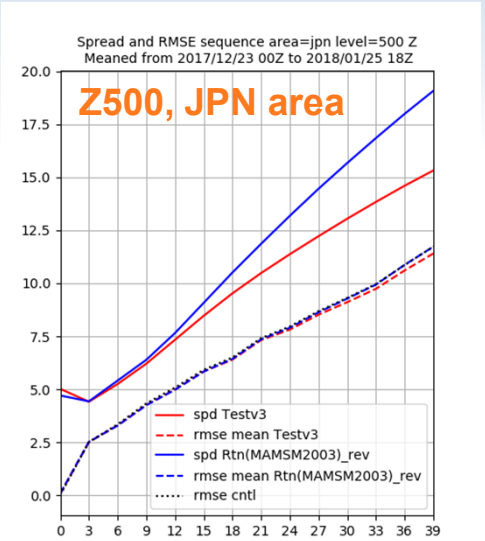




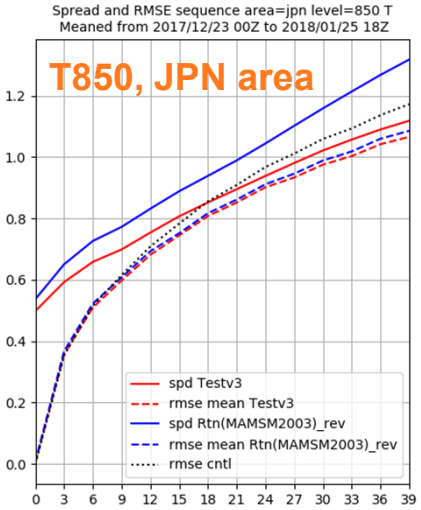
Ensemble spread (winter)

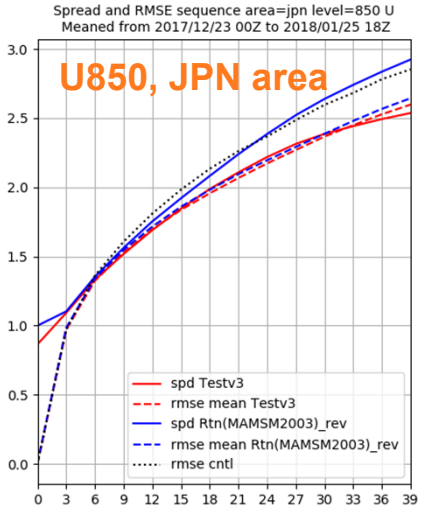


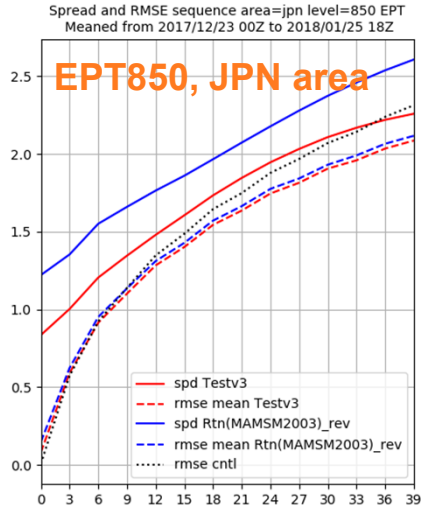




spread, MEPS2009
spread, MEPS1906
RMS error, MEPS2009
RMS error, MEPS1906







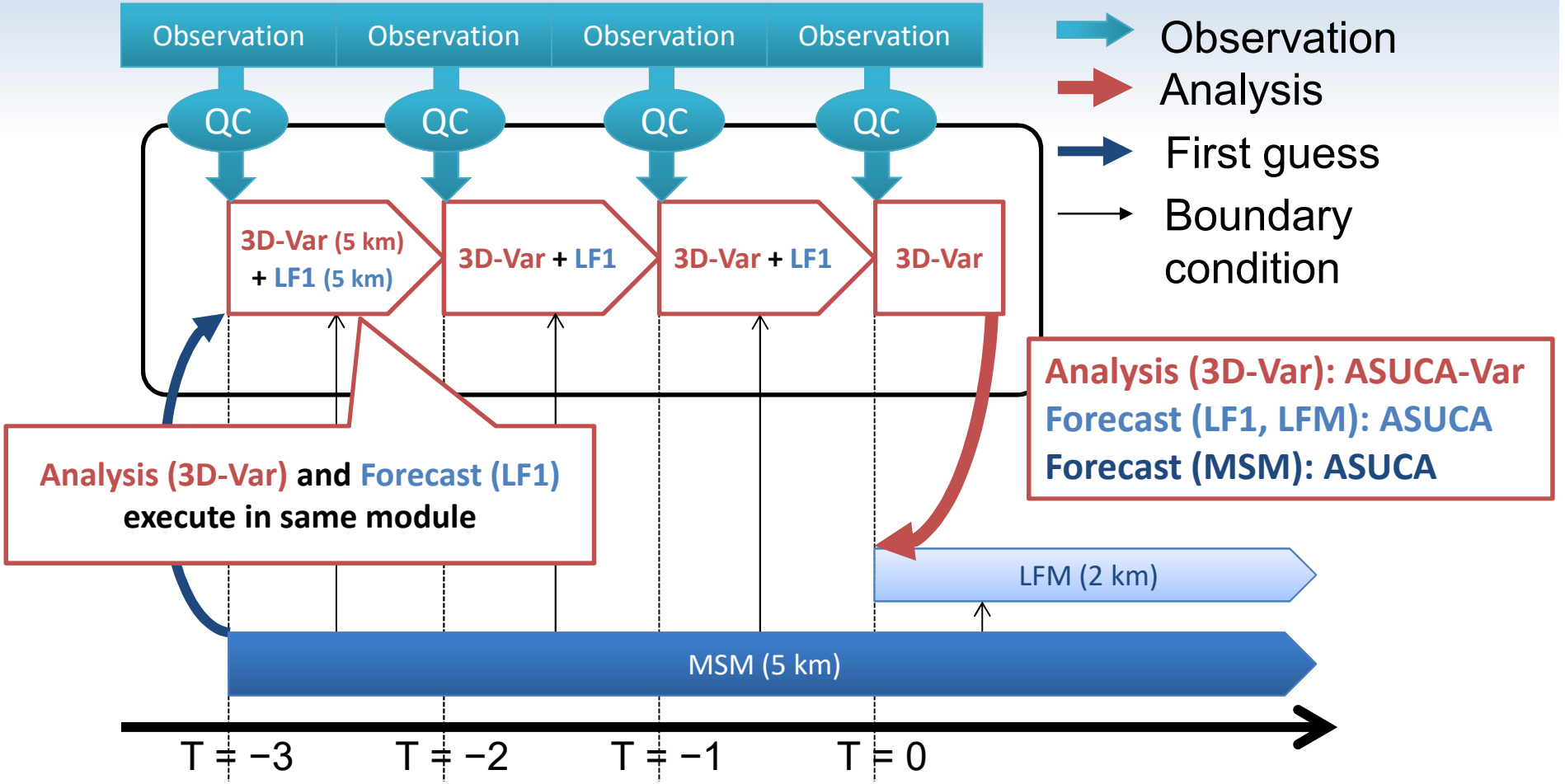
Future plans

- Improving physics schemes and increasing vertical layers of MSM
- Incorporation of hybrid data assimilation into MSM and LFM
- Incorporation of ASUCA-based singular vector into MEPS

References

- Ikuta, Y., H. Kusabiraki, K. Kawano, T. Anzai, M. Sawada, M. Ujiie, S. Nishimoto, Y. Ota, and M. Narita, 2020: A new data assimilation system and upgrading of physical processes in JMA's Meso-scale NWP System. *CAS/JSC WGNE Res. Activ. Atmos. Oceanic Modell.*, **50**, 01.07–01.08.
- Ono, K., M. Kunii, and Y. Honda, 2020: The regional model-based Mesoscale Ensemble Prediction System, MEPS, at the Japan Meteorological Agency. *Quart. J. Roy. Meteor. Soc*. (accepted)

(Supplement) Local analysis cycle



Assimilate the latest observations through 3-h analysis cycle (iterate 3D-Var + 1-h forecasts) using MSM forecast (initialized with 4D-Var) as the first guess

Data cut off time: 30 minutes, Resolution: 5 km