ASSIMILATION EXPERIMENTS OF HIMAWARI-8 RAPID SCAN ATMOSPHERIC MOTION VECTORS

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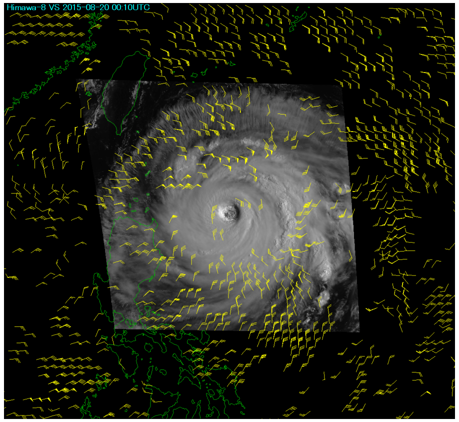
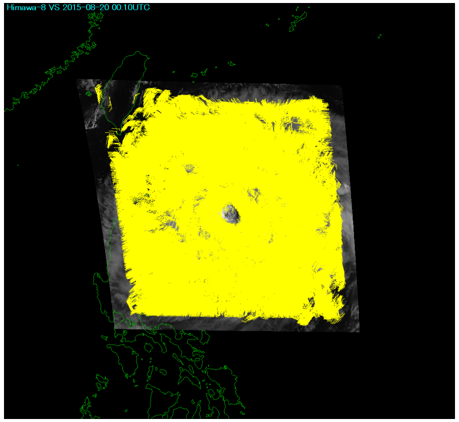
Purpose

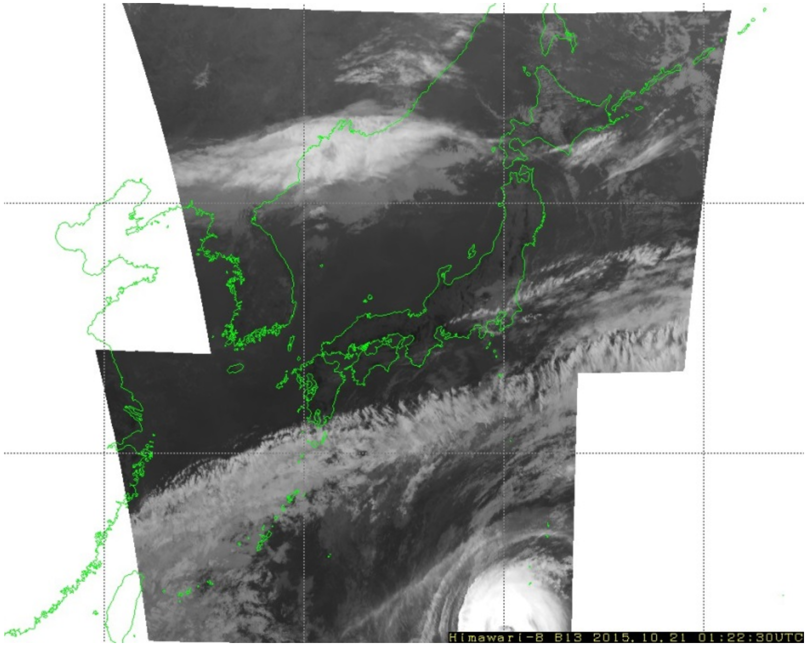
Improve the accuracy of short-range forecasts of heavy rainfalls and other meso-scale severe weathers by utilizing high temporal and spatial resolution Himawari-8 AMVs for assimilation



AMVs around a typhoon derived from 10-min. full disk scan using IR channel (Δ2km)



2.5-min. RS-AMVs using IR (Δ2km) and VIS (Δ0.5km)

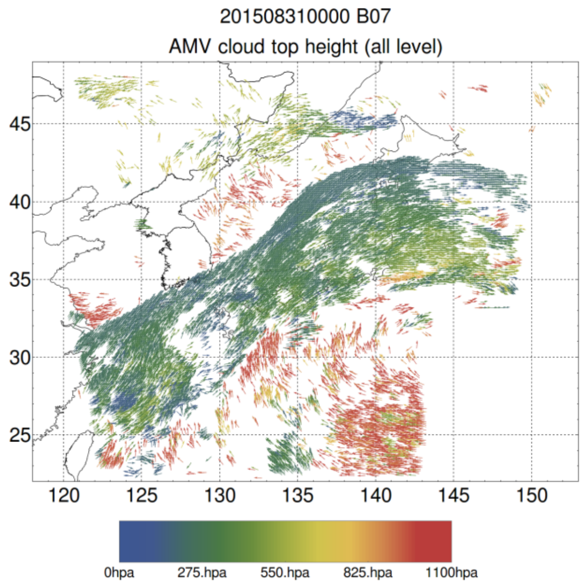


2.5-min rapid scan area around Japan

Himawari-8 Rapid Scan AMV

- Derived from 2.5-min. rapid scans around Japan
- 5-min. interval time for AMV retrieval
- Produced every 15-min. in six bands
- The same AMV software as used in deriving full-disk AMVs

(Shimoji 2014)



B07 RS-AMV at 00:00 UTC, 31st Aug. 2015

Band	Wave length [μm]
B03	0.64
B07	3.9
B08	6.2
B09	6.9
B10	7.3
B13	10.4

Validation and Observation Error Statistics

♦Validation with

- ➢JMA meso-analysis
- ➢Sonde
- ➢Wind Profiler (WPR)

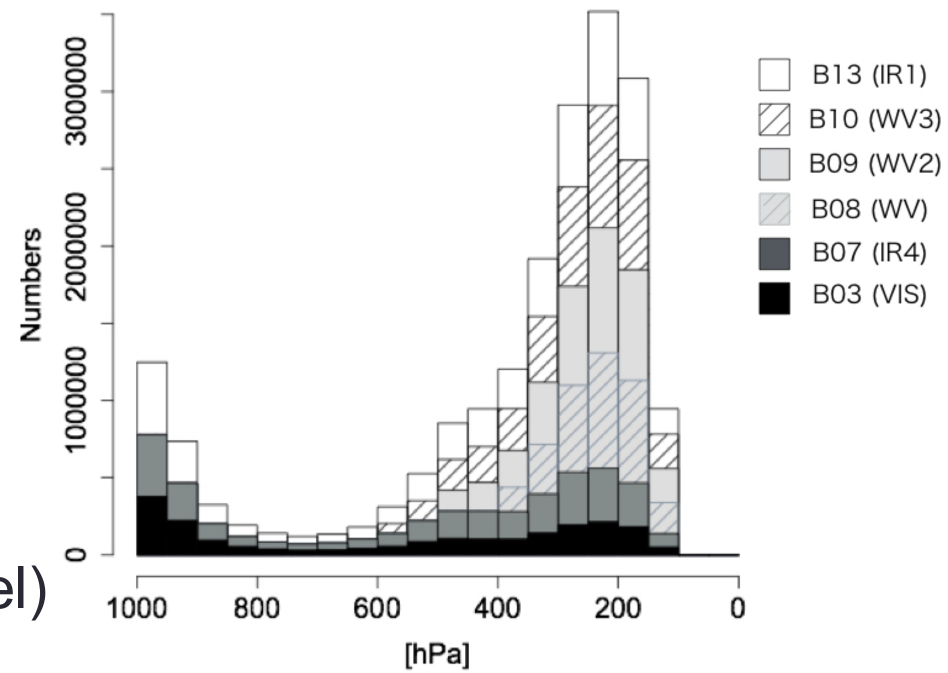
during 1st – 31st Aug. 2015

♦Observation Error statistics

FG departure covariances were derived using differences from NHM (JMA non-hydrostatic model) forecast winds

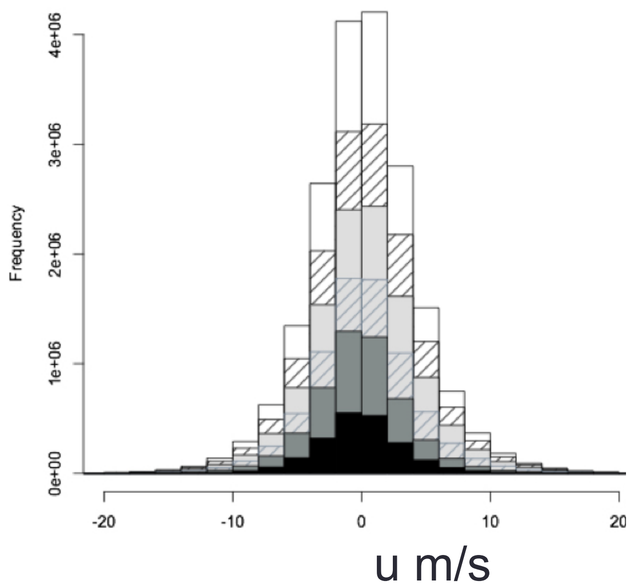
- ➢ Horizontal correlations
- ➢ Interband correlations

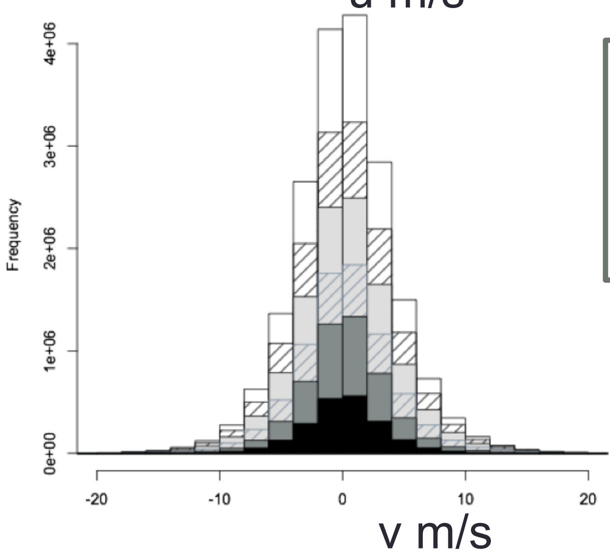
during 1st – 15th Aug. 2015



Number of observations（Aug. 2015）

Validation with JMA meso analysis



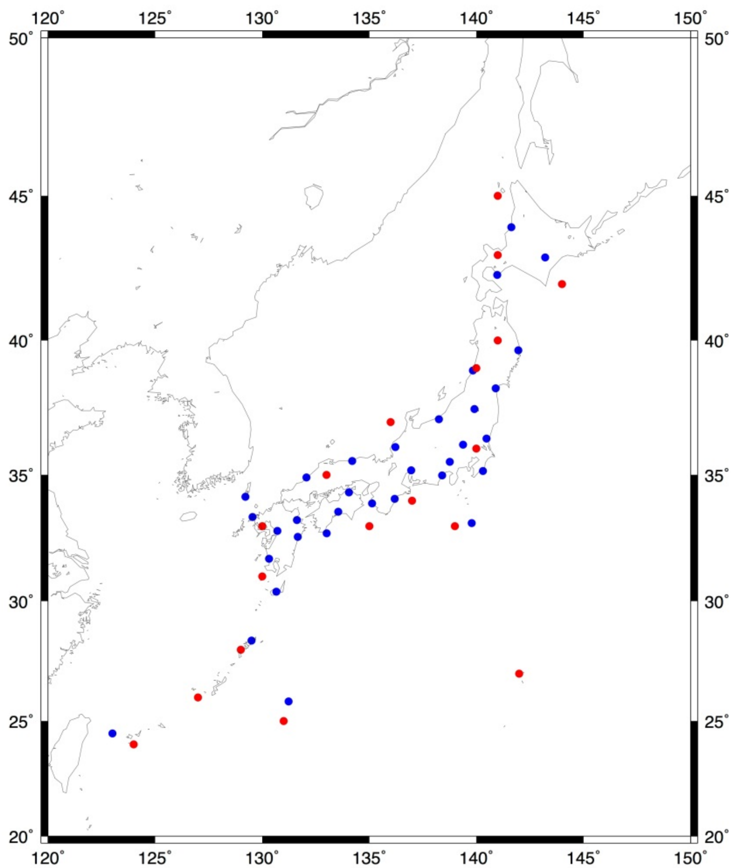


Averaged differences (RS-AMV minus JMA meso analysis) in Aug. 2015

	RMSVD	RMSE		ME	
		u	v	u	v
B03	5.19	3.74	3.60	-0.11	0.08
B07	5.40	3.92	3.72	-0.21	0.24
B08	6.93	4.96	4.83	0.70	0.32
B09	6.70	4.80	4.67	0.50	0.20
B10	6.50	4.64	4.55	0.34	0.18
B13	5.72	4.12	3.97	0.09	0.17

[m/s]

Validation with Sonde/WPR Observations



●: Sonde ●: WPR

Sonde	RMSVD	RMSE		ME	
		u	v	u	v
B03	7.17	5.33	6.37	-0.18	0.17
B07	6.97	5.18	4.66	-0.22	0.14
B08	8.38	6.19	5.66	0.73	0.13
B09	8.13	6.00	5.48	0.56	0.05
B10	7.89	5.83	5.31	0.42	0.07
B13	7.22	5.35	4.86	0.13	0.04

<= 150km, ±25hPa, 1.5-hrs.

WPR	RMSVD	RMSE		ME	
		u	v	u	v
B03	5.62	4.10	3.84	0.31	-0.37
B07	5.61	4.09	3.85	0.46	-0.32
B08	7.58	5.58	5.12	2.55	-0.38
B09	7.26	5.25	5.01	1.89	-0.54
B10	6.71	4.83	4.65	1.41	-0.49
B13	5.92	4.29	4.08	0.72	-0.35

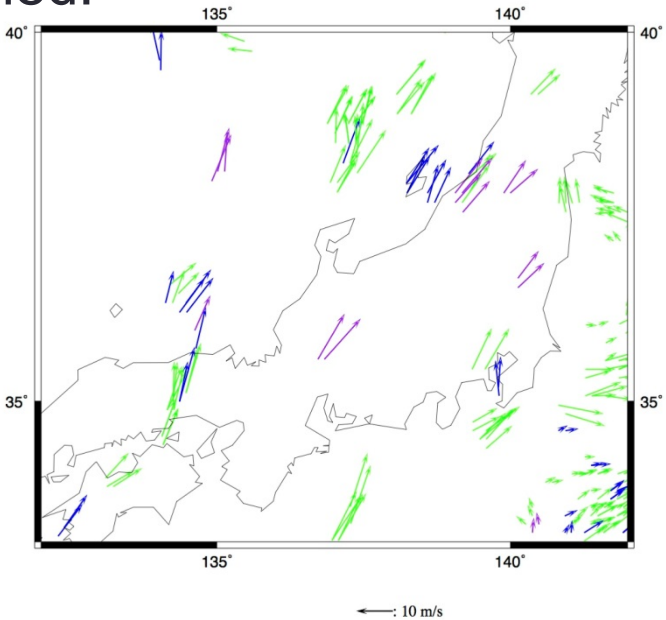
<= 50km, ±10hPa, 5-min.

Low-level RS-AMVs over Land

Many low-level AMVs over land were obtained.

Differences in VIS and IR
(Aug. 2015)

WPR		RMSE		ME		Count
		u	v	u	v	
Lower (>700hPa)	B03	3.74	3.28	0.23	-0.06	37473
	B07	3.79	3.40	0.42	0.09	42120
	B13	4.00	3.67	0.62	0.15	51575
Mid (400-700hPa)	B03	4.12	3.93	-0.40	-0.59	75665
	B07	4.05	3.93	-0.15	-0.57	123700
	B13	4.23	4.15	-0.07	-0.64	154125
Upper (<=400hPa)	B03	4.10	3.84	1.01	-0.32	82524
	B07	3.91	4.22	1.08	-0.22	124757
	B13	4.43	4.14	1.48	-0.24	166021



Low-level RS-AMV (>700hPa)
03:00 UTC 17th Aug. 2015

→ : > 900hPa
→ : 900 – 800 hPa
→ : 800 – 700 hPa

Tendency toward High QI

Quality Indicator (Homlund 1998)

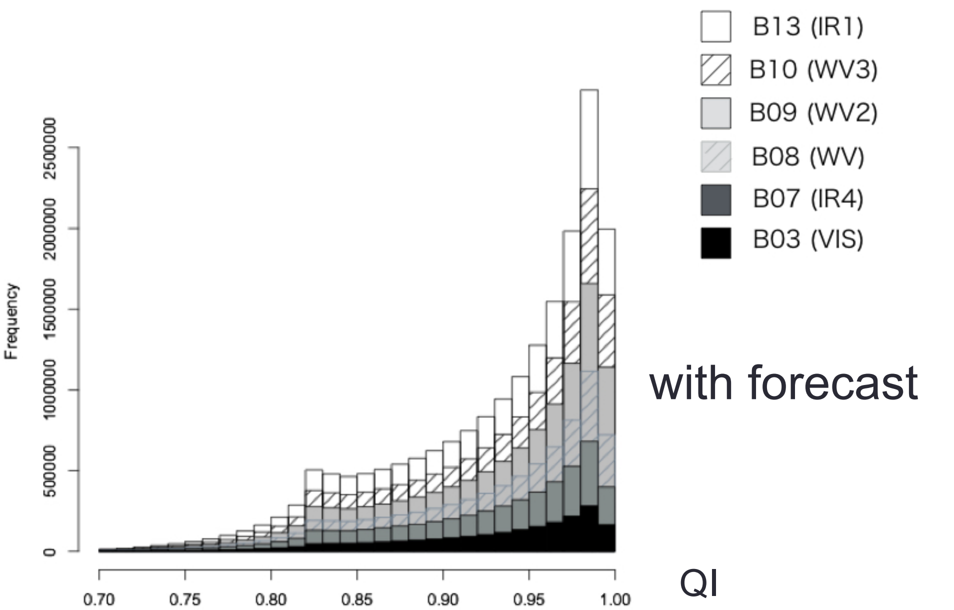
Difference from JMA meso analysis by QI (RMSVD [m/s])

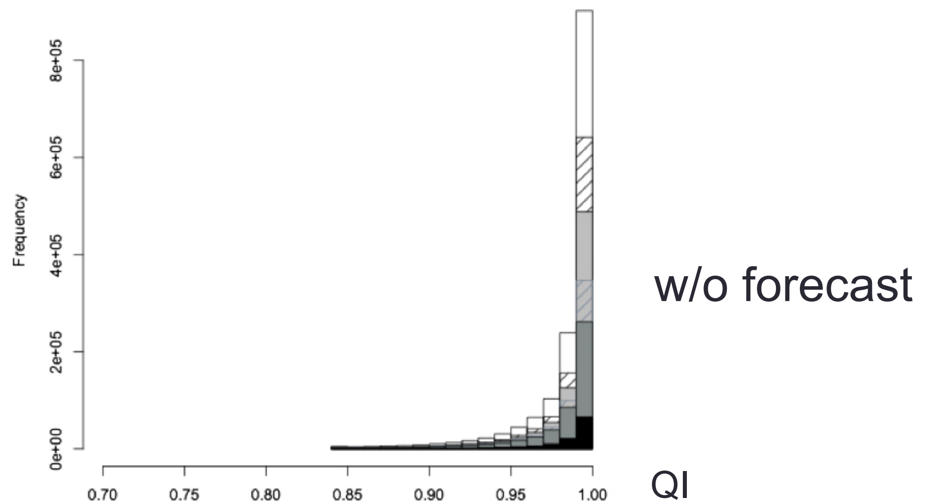
	0.8 - 0.9	0.9 - 1.0	1.0
B03	5.47	3.98	3.59
B07	8.65	4.07	3.65
B08	14.39	7.28	4.64
B09	12.12	6.91	4.62
B10	10.62	6.62	4.56
B13	6.18	4.45	4.03

with forecast

	0.8 - 0.9	0.9 - 1.0	1.0
B03	5.16	4.43	3.91
B07	5.30	4.62	5.03
B08	10.50	7.73	6.76
B09	9.31	7.31	6.28
B10	8.61	6.80	6.12
B13	5.66	4.79	4.51

w/o forecast

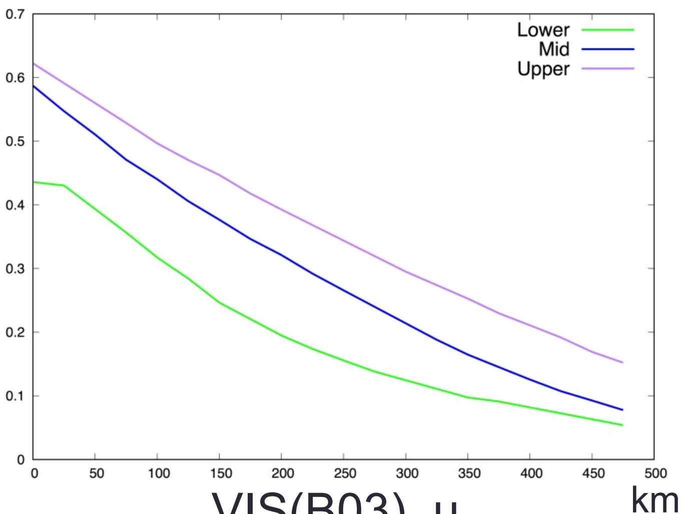




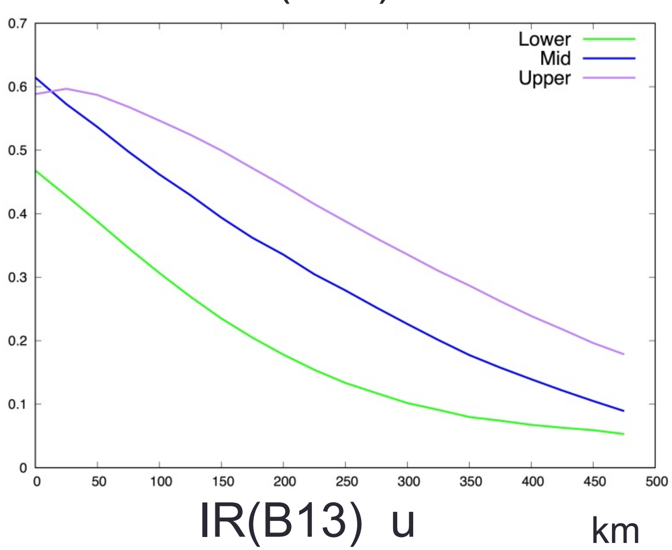
Number of RS-AMVs by QI (Aug. 2015)

Correlations of Observation Error

Horizontal correlation



VIS(B03) u



IR(B13) u

Inter-band Correlation

		B03	B07	B08	B09	B10	B13
B03	L		0.44	-	-	-	0.45
	M		0.56	-	0.55	0.56	0.57
	U		0.59	0.61	0.62	0.62	0.62
B07	L			-	-	-	0.46
	M			-	0.57	0.58	0.59
	U			0.63	0.63	0.63	0.63
B08	U				0.63	0.63	0.63
B09	M					0.60	0.57
	U					0.63	0.63
B10	M						0.59
	U						0.63

L: Lower
M: Mid
U: Upper

Correlations of FG covariances between pairs of RS-AMVs in the same 3-hour time windows

Error Characteristics

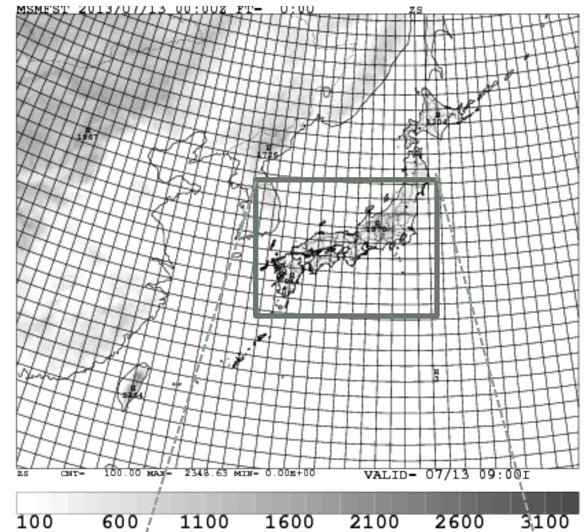
- The quality of Himawari-8 RS-AMVs is good enough for assimilation. Low-level RS-AMVs over land also seem to have a good quality when compared with WPR observations.

- RMSVDs in WV bands (B08, 09 ,10) were slightly bigger than those in VIS or IR bands and showed slight positive biases.

- Data selection for assimilation - Which data is more meaningful ?
  - Additional QC than QI may be necessary
  - Band selection ?
  - How to form super observation ? Data thinning ?

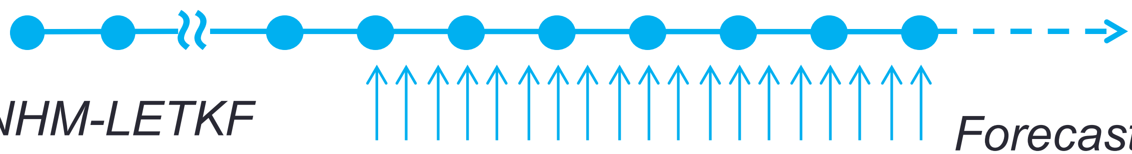
Assimilation Experiment Settings

- NHM-LETKF (Kunii 2014)
  - The local ensemble transform Kalman filter (LETKF) implemented with the Japan Meteorological Agency's nonhydrostatic model (NHM)
- Δ15 km･50 layers, 50 members
- Localization : 200 km/0.2 lnP
- 3-hour window, 1-hour time slot



15-km assimilation domain

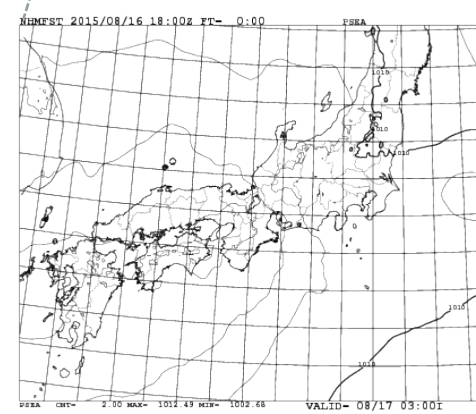
00 UTC Aug. 10th | 00 UTC Aug. 16th | 18 UTC Aug. 16th



NHM-LETKF Start

Assimilation of RS-AMV

Forecast



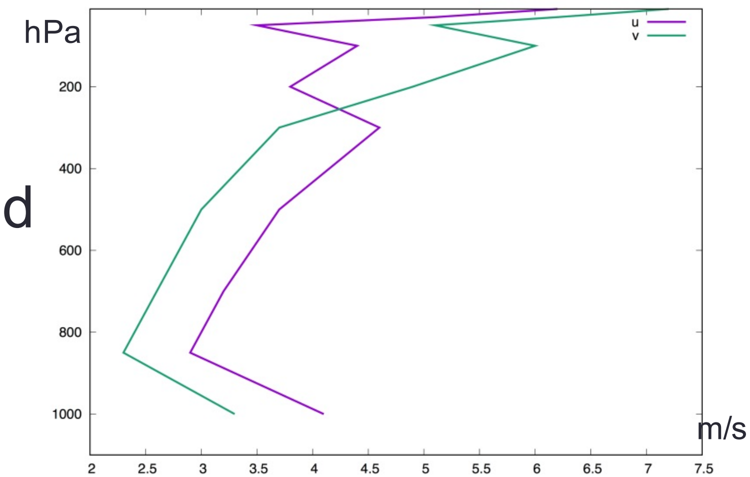
5-km forecast domain

CNTL: Observational data used for operational JMA meso-analysis

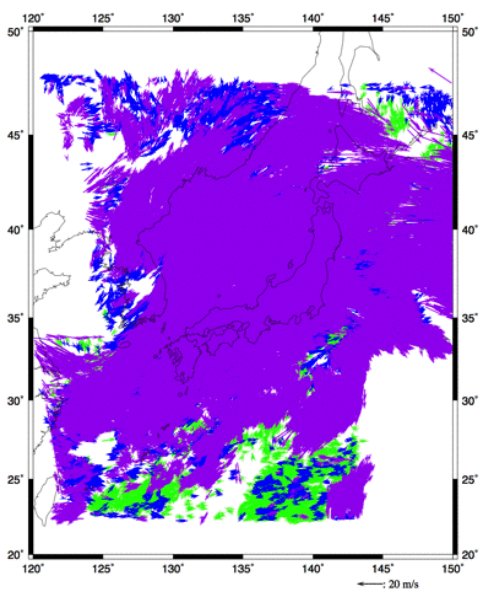
TEST: CNTL data + RS-AMV

RS-AMV Super Observation

- 00- 18 UTC 16th Aug. 2015
- Super observation (Δ50 km・50 hPa at low level, Δ100 km ・100 hPa at high and mid level)
- Himawari-8 RS-AMVs in B03, B10 and B13 were combined into one SPOB every hour on the hour



Observation Error of RS-AMV



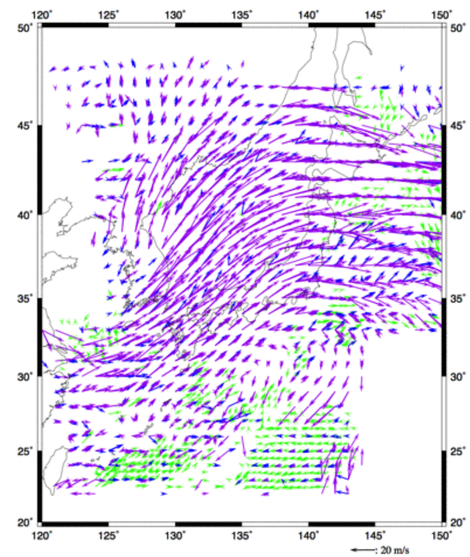
RS-AMV

Averaged

High (<400hPa)

Mid (400-700hPa)

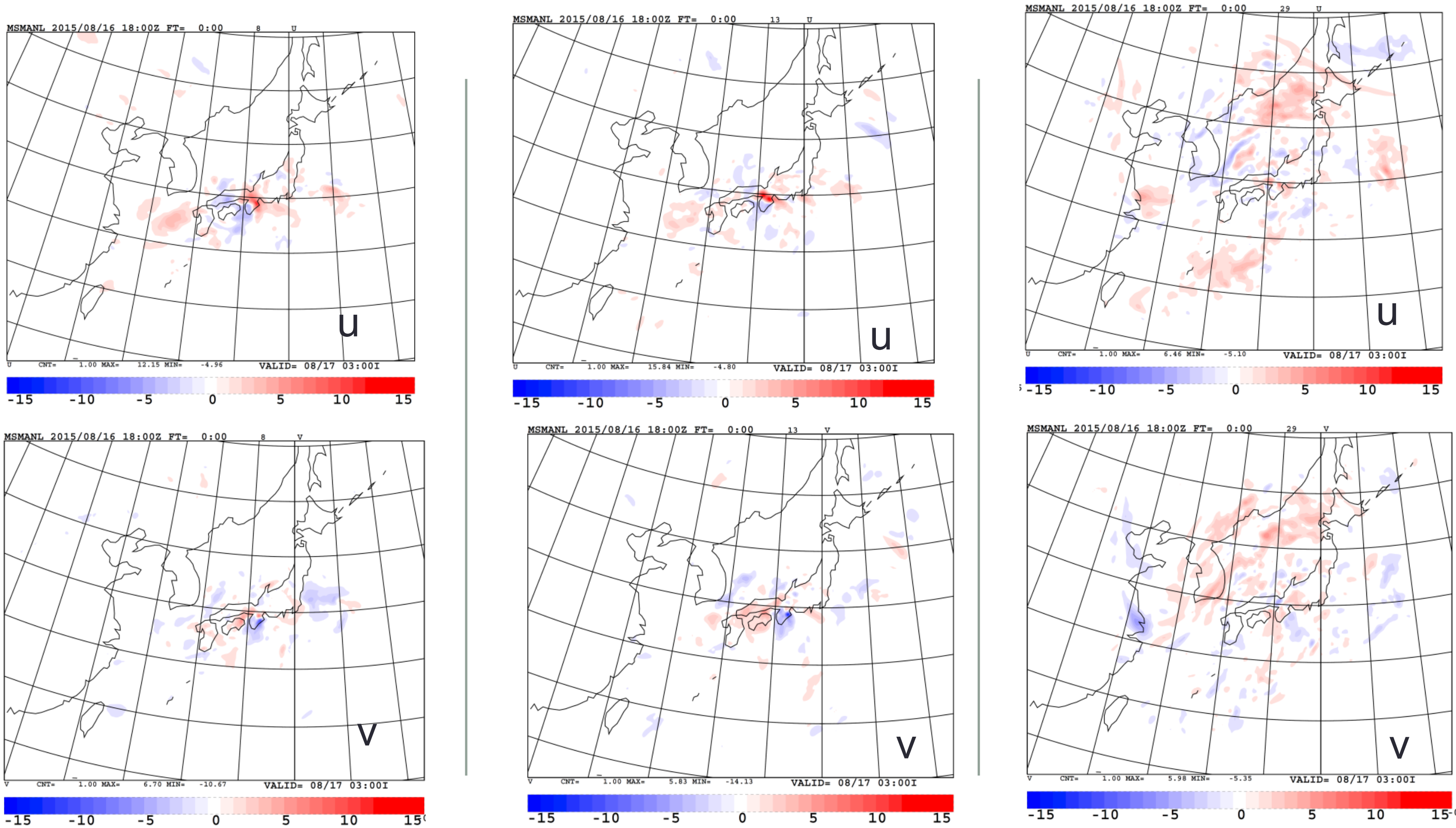
Low (>700hPa)



RS-AMV SPOB

Results – Increment

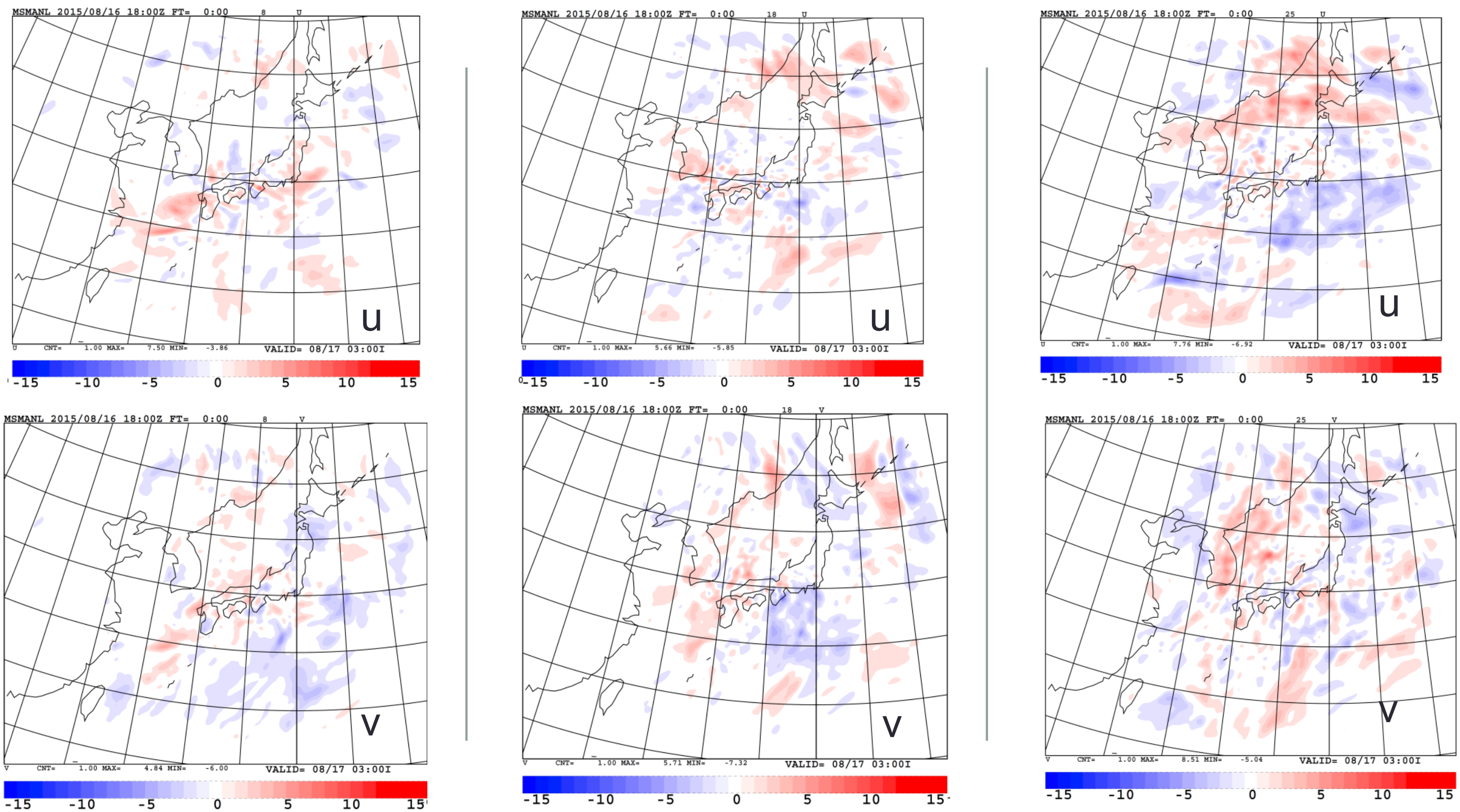
- Increment of u- and v- wind component (Analysis– First Guess) at 18 UTC on Aug. 16th in TEST



Surface(500 m) 850 hPa 400 hPa

Results - Analysis

- Difference of analysis (TEST – CNTL) at 18 UTC on Aug. 16th
  - Upper Panels : u (m/s), Lower Panels : v (m/s)

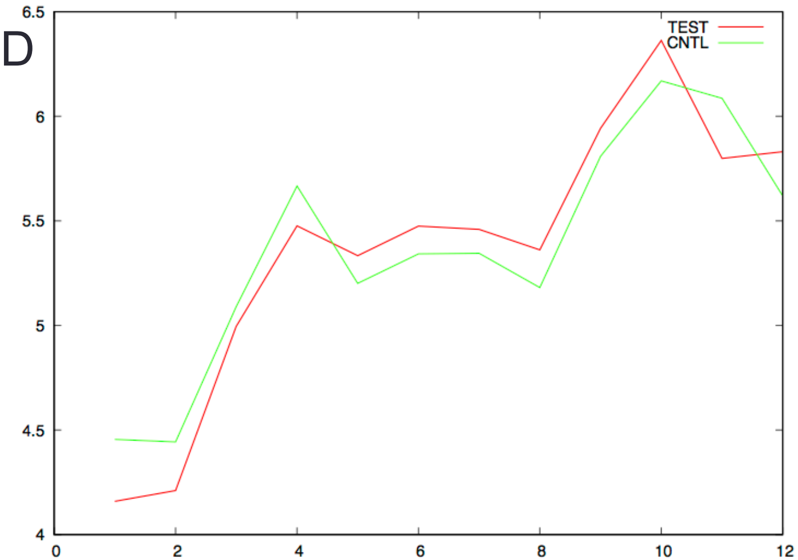


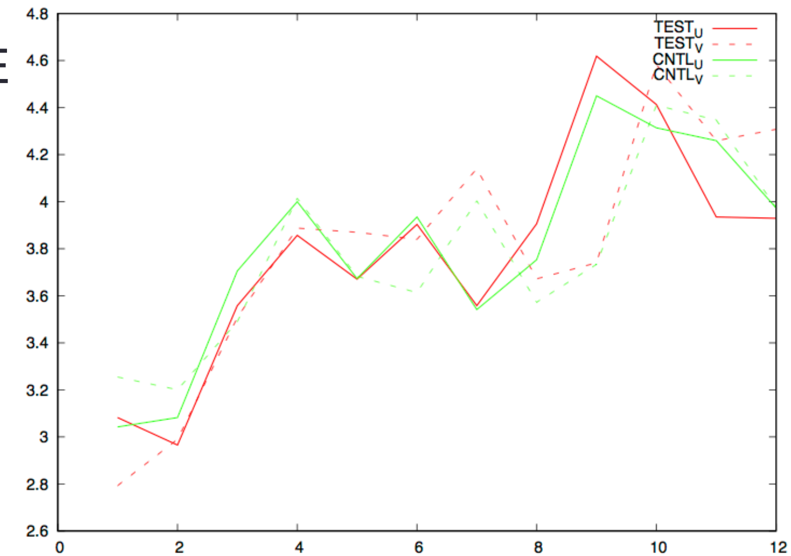
Surface(500 m) 700 hPa 400 hPa

Results –Wind forecast

- Forecast winds compared with WPR observations

Averages of 27 wind profiler stations

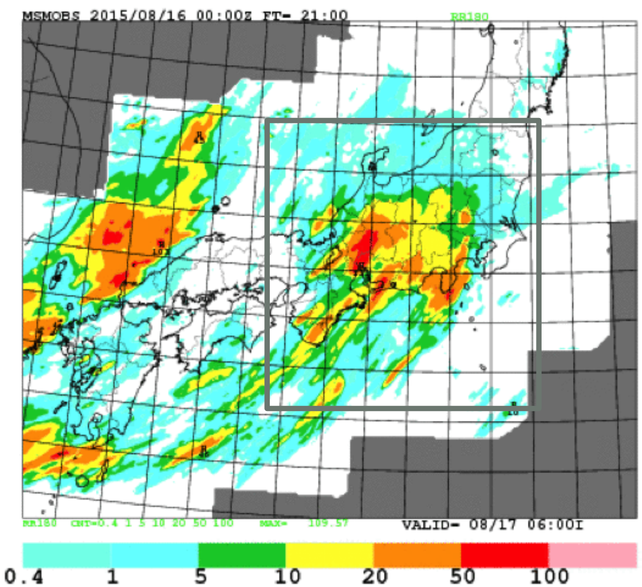




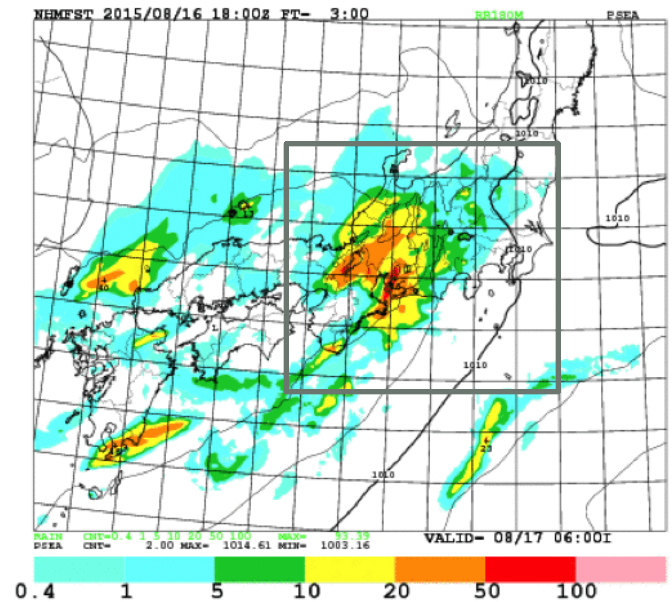
	RMSVD (m/s)			
	Low	Mid	High	All
TEST	5.19	5.35	5.46	5.35
CNTL	5.32	5.35	5.51	5.38

Results – Rainfall forecast

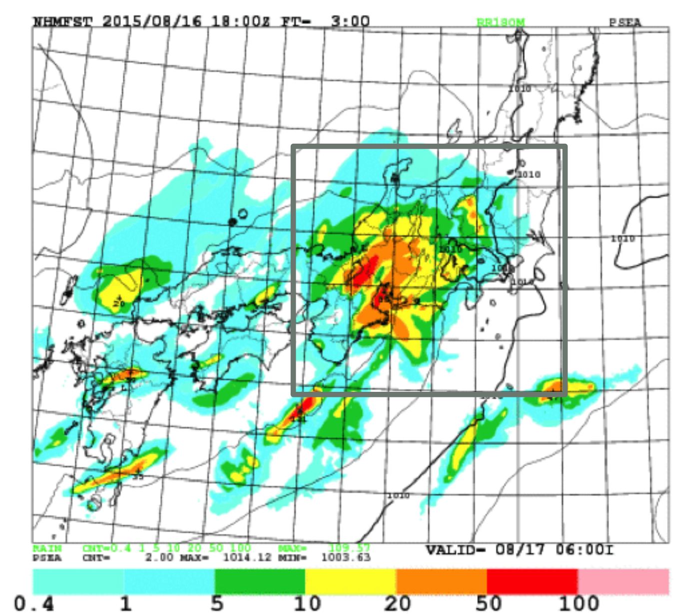
3-hour amount of rainfall
FT = 03, 06, 09, 12



Observation



TEST

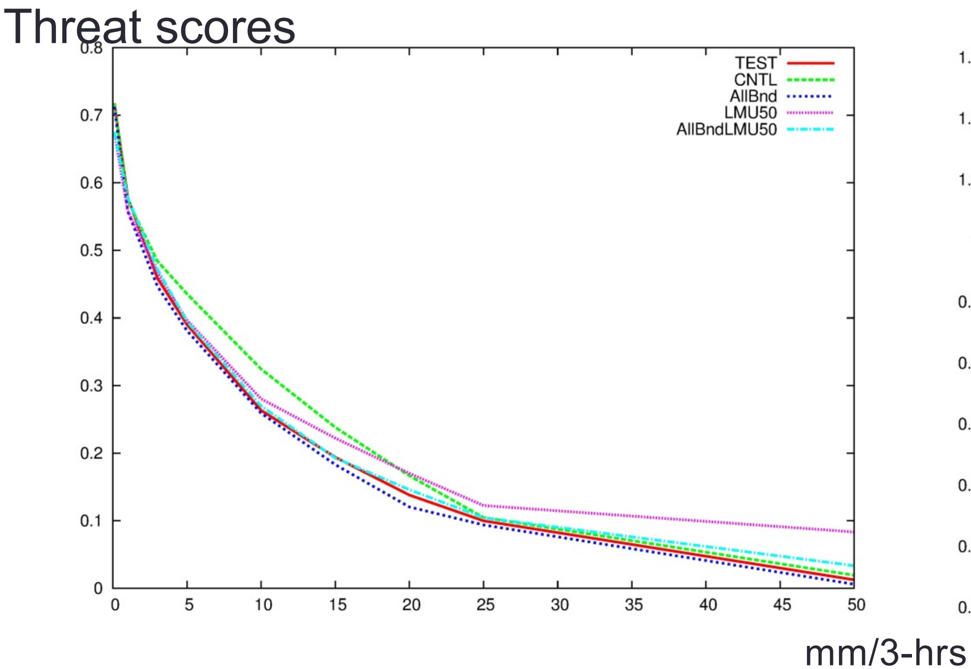


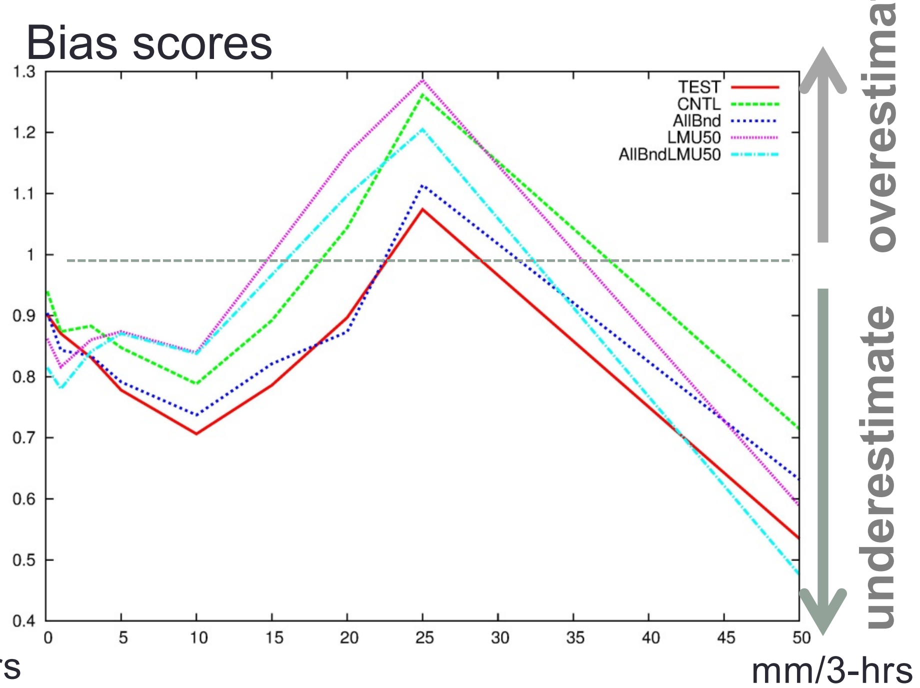
CNTL

RS-AMVs were assimilated in different experiments

Experiments	Levels	Bands	Resolutions	Objectives of experiment
TEST	Low+Mid+High	B03, B10, B13	50km(Low), 100km(Mid, High)	-
AllBnd	Low+Mid+High	All 6 bands	50km(Low), 100km(Mid, High)	Error correlation of inter-bands
LMU50	Low+Mid+High	B03, B10, B13	50km(Low, Mid, High)	Error correlation of horizontal distances
AllBndLMU50	Low+Mid+High	All 6 bands	50km(Low, Mid, High)	Both
Low RS-AMV	Low	B03, B10, B13	50km(Low)	Impacts of low-level winds
High and Mid RS-AMV	Mid+High	B03, B10, B13	100km(Mid, High)	Impacts of High- and Mid-level winds

Results – Rainfall Forecast Scores

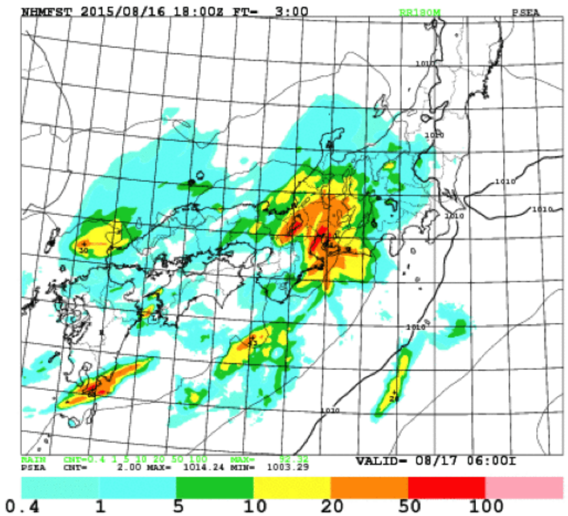




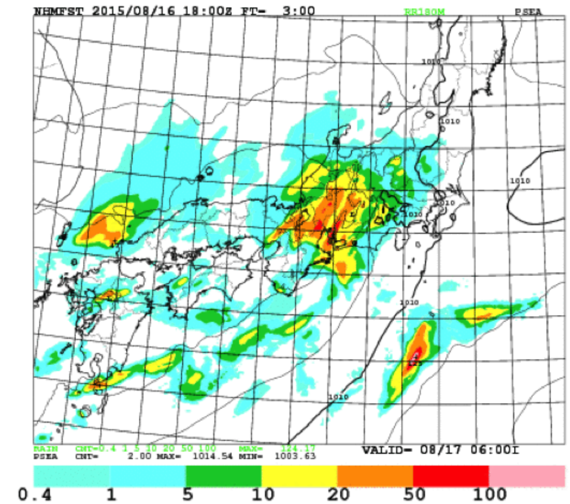
Threat and bias scores averaged over the whole forecast period (up to 12 hrs.)

- TEST is slightly better in scores of light rain but worse in case of heavy rain than CNTL.
- 50 km is better than 100 km ?
- The selection of bands (B03, B10, B13) seems better in this case.

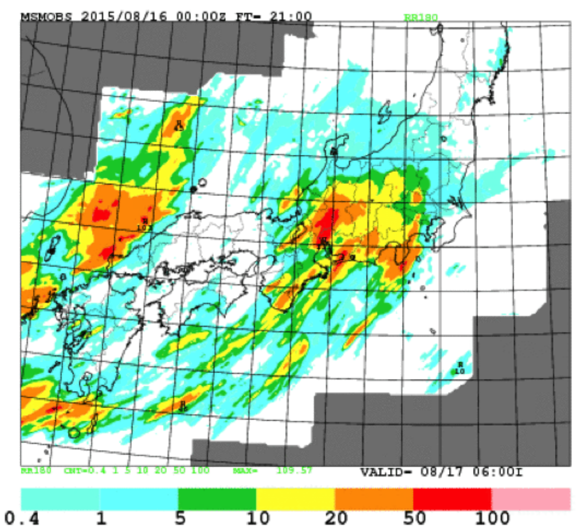
Impact of Low- and High/Mid- level AMV ?



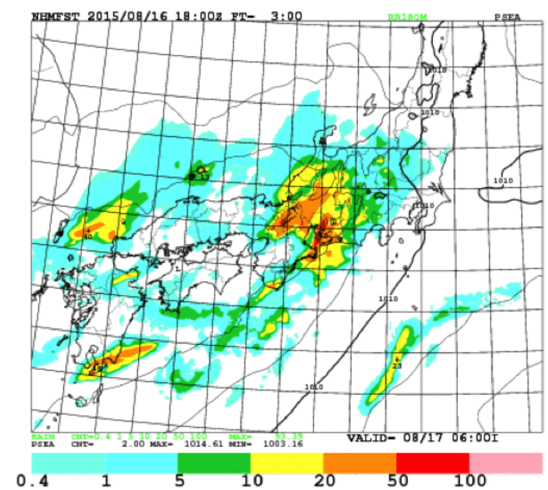
Low RS-AMV



High and Mid RS-AMV

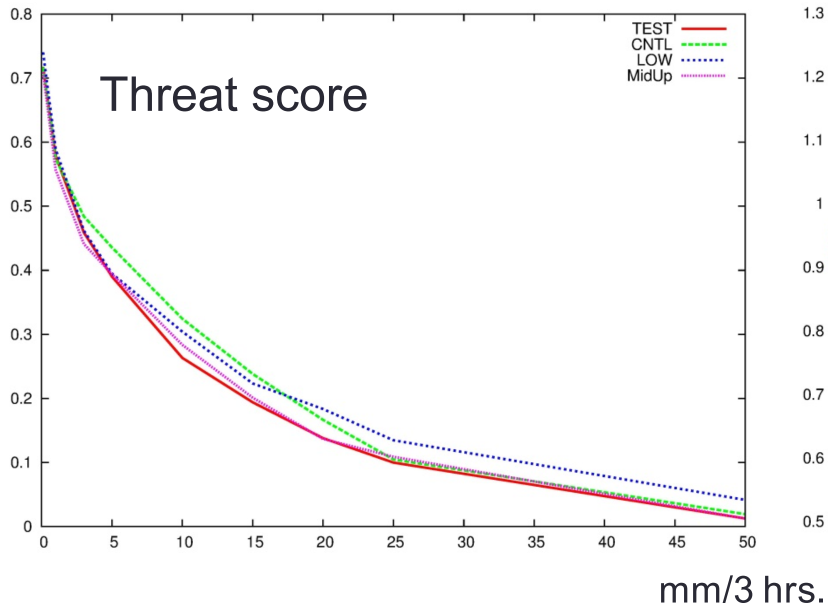


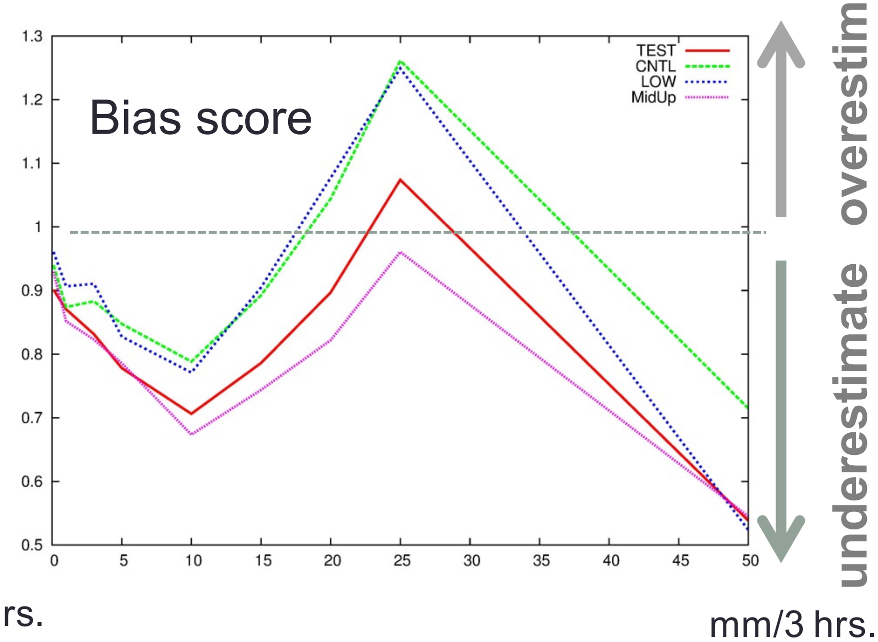
Observation



TEST

Results – Rainfall forecast





Threat and bias scores averaged over the whole forecast period (up to 12 hrs.)

LOW : Only low-level RS-AMVs were assimilated.
MidUp : Only mid- and high-level RS-AMVs were assimilated.

- Low RS-AMVs seem to have more positive impact than mid- and high-level RS-AMVs in this case.

Results of Assimilation Experiments

- Assimilation Experiments of Himawari-8 RS-AMVs on a heavy rainfall event on 17th Aug. 2015 were conducted.
- TEST is slightly better in scores of light rain but worse in case of heavy rain than CNTL.
- When only low-level RS-AMVs were assimilated, it showed better rainfall forecast scores than TEST and comparable to TEST. Tuning of mid- and high-level RS-AMVs in SPOB may be a key issue.
- The experiments assimilating RS-AMVs from all six bands were worse than the experiments using the selected three bands.

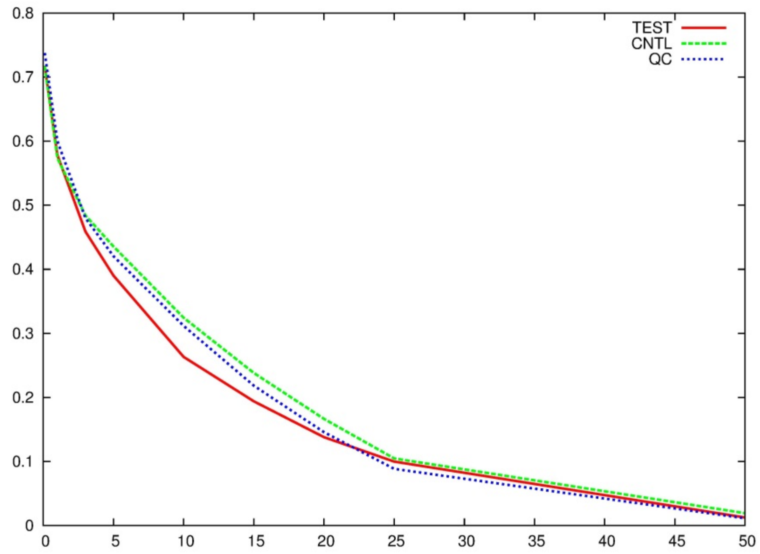
Summary

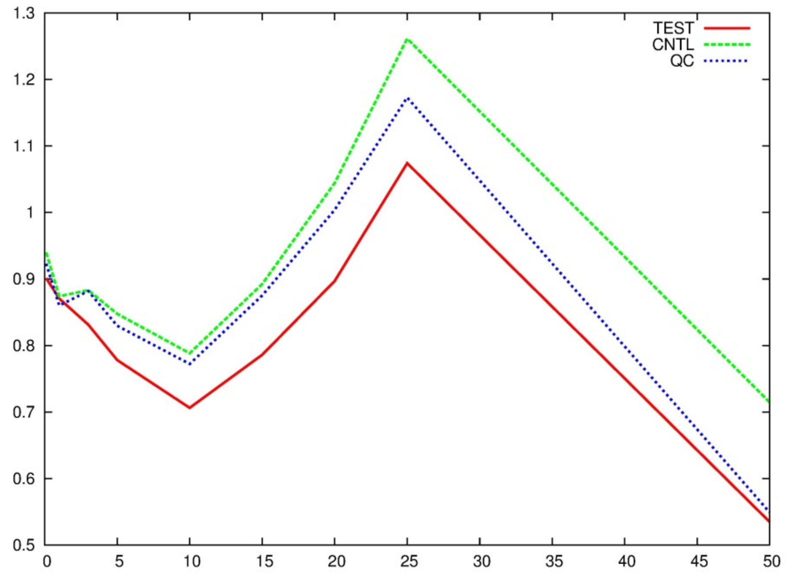
- The Data quality and the characteristics of observation errors of RS-AMVs were examined using the statistics of differences from JMA mesoscale analyses, radiosonde observations and NHM forecasts. Data assimilation experiments using NHM-LETKF (Kunii 2014) on a heavy rainfall event were conducted to see the impact of RS-AMVs on analyses and forecasts of wind and rainfall.

- In order to make full use of these high resolution data and to avoid observation error correlations in space, time and inter-band, the strategies for quality control, formation of super observations or data thinning should be well considered.

- We need further investigation about how to utilize RS-AMVs in our data assimilation system more effectively.

Thank you for your attention.





QC: SPOB is not formed when

- the STD of all the RS-AMVs in the prism exceeds the threshold
- the number of data in the prism is less than ten