Observing System Experiment of MTSAT-1R Rapid Scan AMV using the JMA operational NWP system from 2011 to 2013

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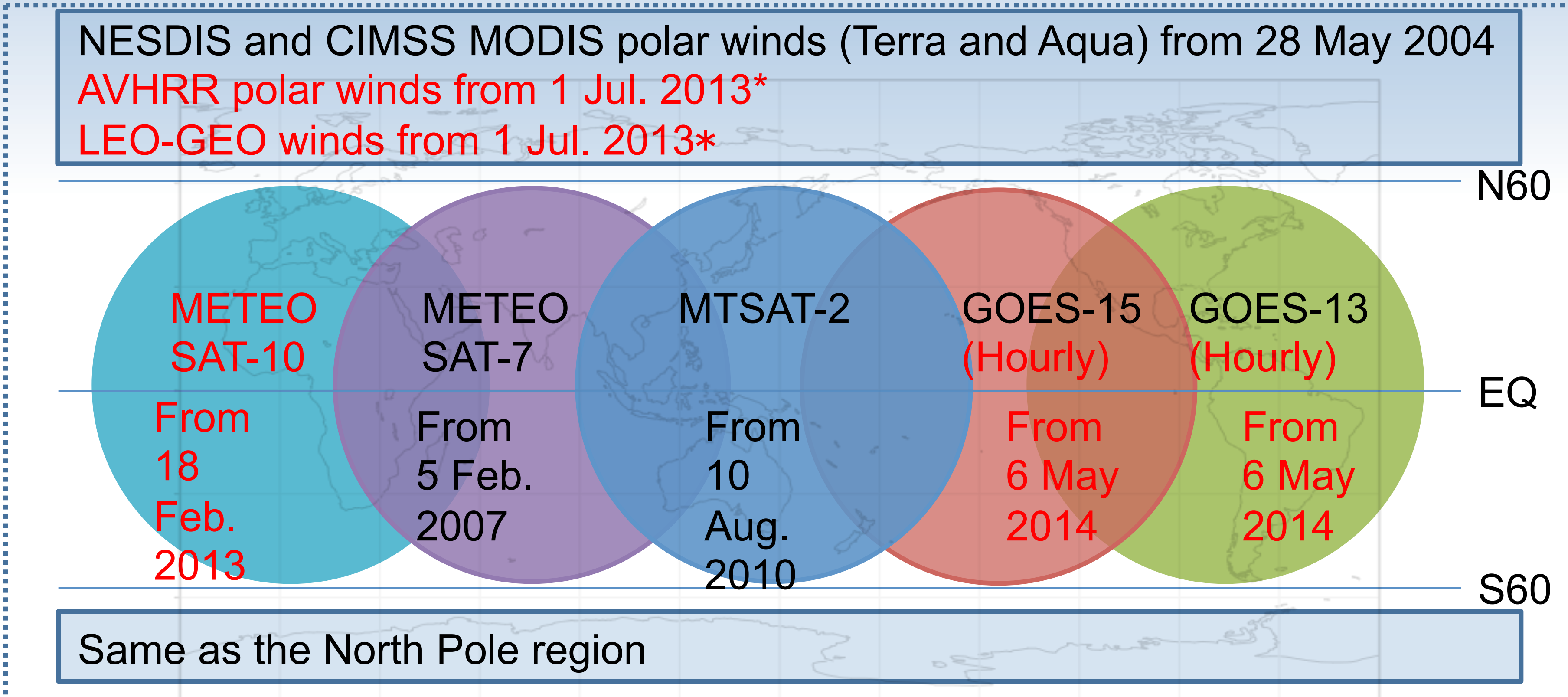
Outline

- AMV Satellite Status update for NWP use of JMA
- NWP system for Observing System Experiment (OSE)
- Verification of Rapid Scan AMVs (RS-AMVs)
- OSE for RS-AMVs
  - Using Global NWP system in 2013
  - Using Meso-scale NWP system in 2011 and 2012
  - Using Local NWP system in 2012 (Not shown, only the summary)
- Summary and future plan

AMV Satellite Status update for NWP use of JMA



※ 28 Nov. 2013 Assimilation of Metop-B/AVHRR and ASCAT data started.

* K.Yamashta 2014: Introduction of LEO-GEO and AVHRR Polar Atmospheric Motion Vectors into JMA's Operational Global NWP System. CAS/JSC WGNE Res. Activ. Atmos. Oceanic Model, Submitted.

- In near future plan
  - VIIRS polar winds from Suomi-NPP

NWP SYSTEM FOR OSE

NWP system for OSE

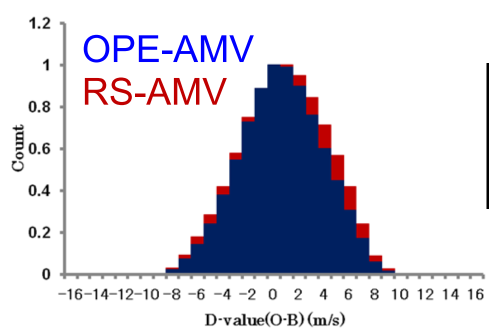
**Not used in OSE	Global	Meso-Scale	Local
Purposes	Short- and medium-range forecasts	Very-short-range forecasts, aviation forecasts	
Forecast domain	Globe	Japan and its surrounding areas	Japan and its surrounding areas
Grid size	20 km	5 km	2 km
Vertical levels/Top	60/0.1 hPa	50/21.8 km	60/20.2 km
Forecast range (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 (hourly)
Initial condition	4D-Var Analysis	4D-Var Analysis	3D-Var Analysis
Time window	6-hour	3-hour	3D-Var analyses and 1-h forecasts are repeated in turn for 3 hours.
Inner-loop model res.	55 km	15 km	5 km


VERIFICATION OF RS-AMVS

Summary for verification of RS-AMVs in 20N-45N and 120E-150E (Japan area)

- Wind speeds of RS-AMVs with the intervals of 5 or 10 minutes were compared to operational AMVs (OPE-AMVs) with 15 or 30 minutes in summer between 2011 and 2013 in GSM first-guess departure (O-B) statistics.
  - Positive bias above 400 hPa in water vapor AMVs (WV-AMVs)
  - Large standard deviation in all sensor AMVs
  - Small spatial observation error correlation
    - Spatial error correlation distances of RS-AMVs and OPE-AMVs were estimate to about 100 km and 200 km respectively when correlation under 0.2 is ignored empirically.

(Ex.) O-B normalized histograms of WV-AMVs From Jun. to Sep. 2012



	Count	ME (m/s)	STD (m/s)
RS-AMV	4738789	0.78	3.38
OPE-AMV	1405513	0.61	3.20

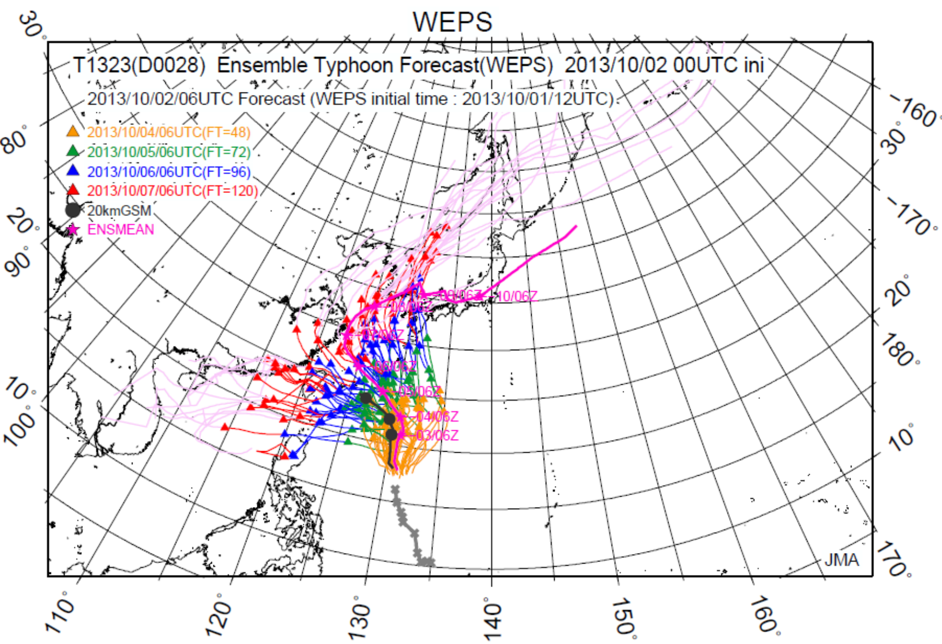
OSE FOR RS-AMVS
USING GLOBAL NWP SYSTEM

Back ground

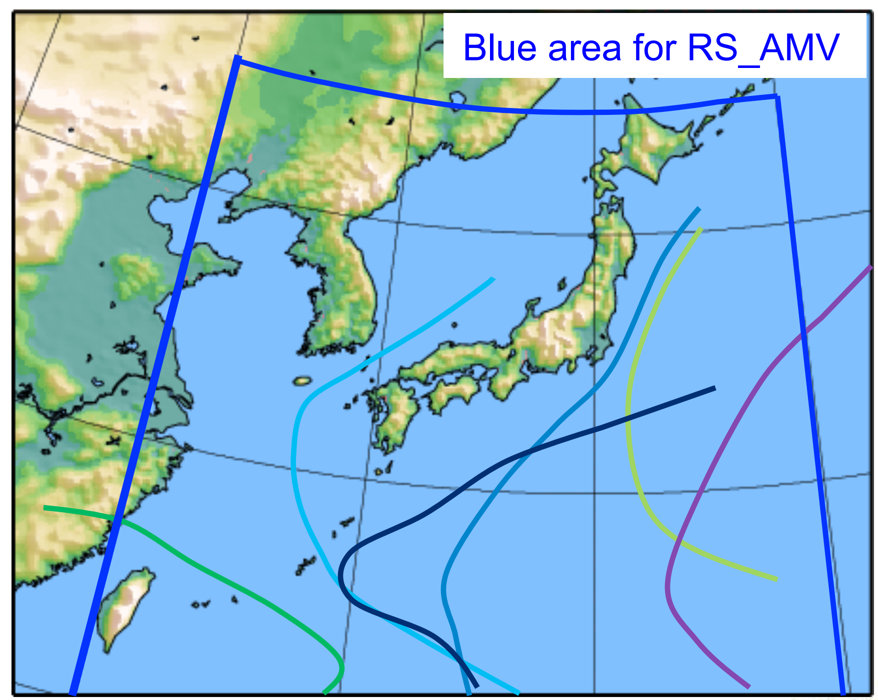
JMA/MSC specially produced RS-AMVs from the satellite images with the intervals of 10 minutes for 24 hours from 2 to 18 October 2013.

Motivation

- To decrease uncertainty of typhoon forecasts such as seen for the typhoon “FITOW”
- To decrease the positional forecast errors of 6 Typhoons (SEPAT, FITOW, DANAS, WIPHA, FRANCISCO and LEKIMA) which were passed around Japan



FITOW EPS at 00UTC 2 October 2013



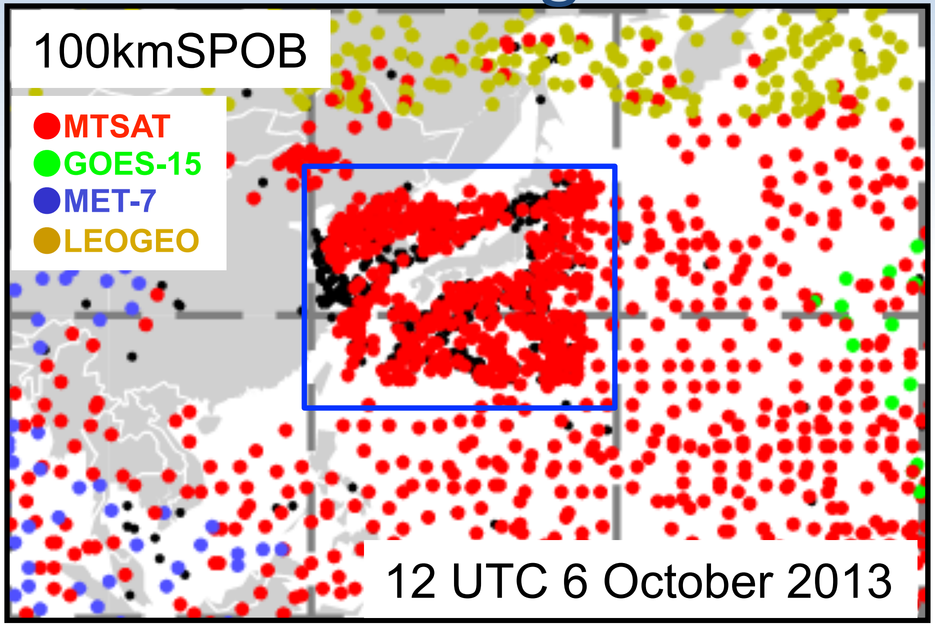
6 Typhoons tracks in October 2013

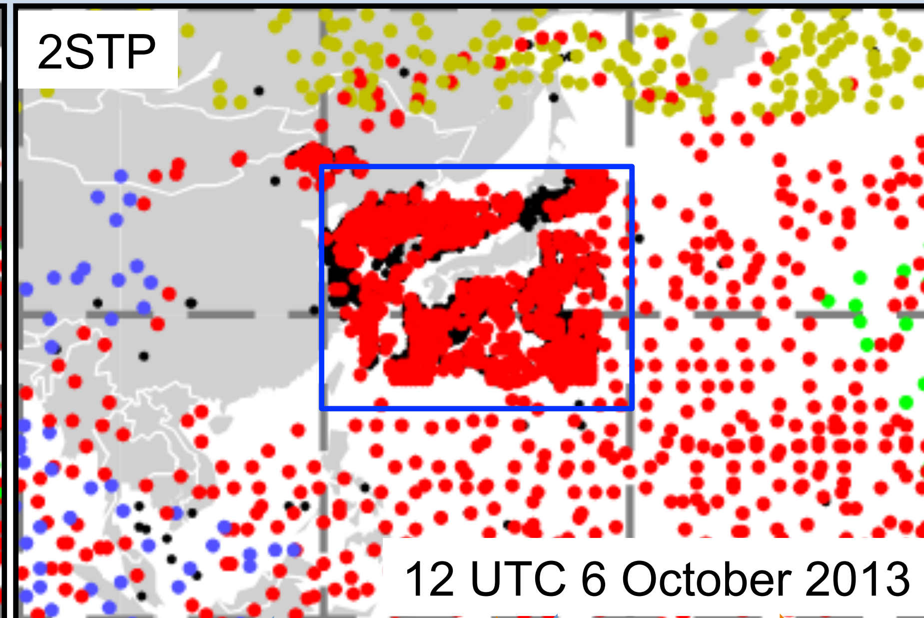
Experimental Design

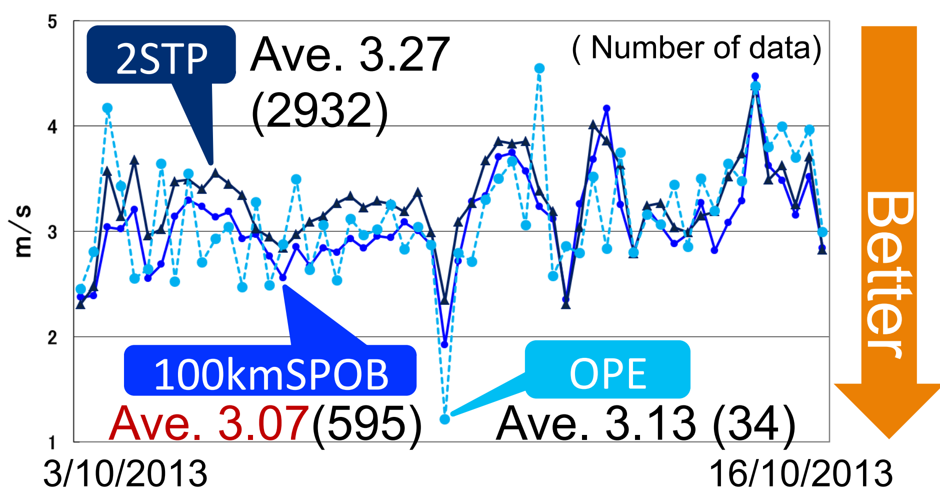
Name	Specification
OPE	A scheme of the 200 km thinning of OPE-AMVs in the 6 hour time window
2STP RS-AMVs(100km thin.) OPE-AMVs(200km thin.)	2-step thinning scheme ➢ A combination scheme of the 100 km thinning of RS-AMVs in 2 hour time window and the 200 km thinning of OPE-AMVs in 6 hour time window
100kmSPOB RS-AMVs(SPOB) OPE-AMVs(200km thin.)	Super-observation procedure (combination scheme) Average of AMVs (RS-AMVs) directions and speeds with 100 km intervals in hourly time window and the 200 km thinning of OPE-AMVs in 6 hour time window ➢ Averaging about time, level, space, wind directions and speeds

- Period:
  - Assimilation : From 2 to 28 October 2013 (including RS-AMV from 2 to 16 October)
  - Forecast : From 2 to 16 October 2013

Data coverage and normalized RMSE difference





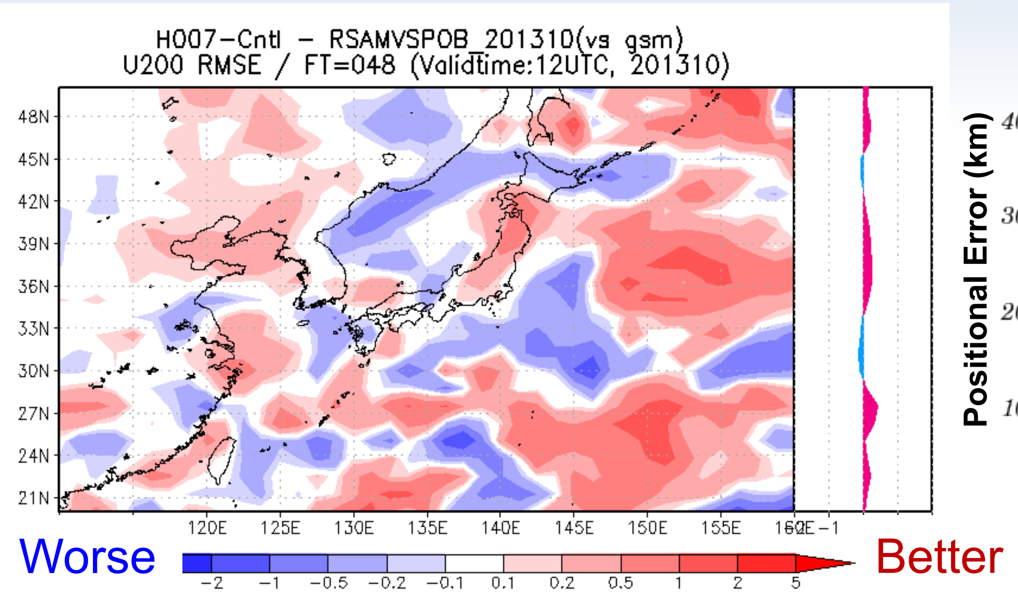


Standard deviation time series of O-B wind speeds above 400 hPa in 20N-45N and 120E-150E (blue rectangle)

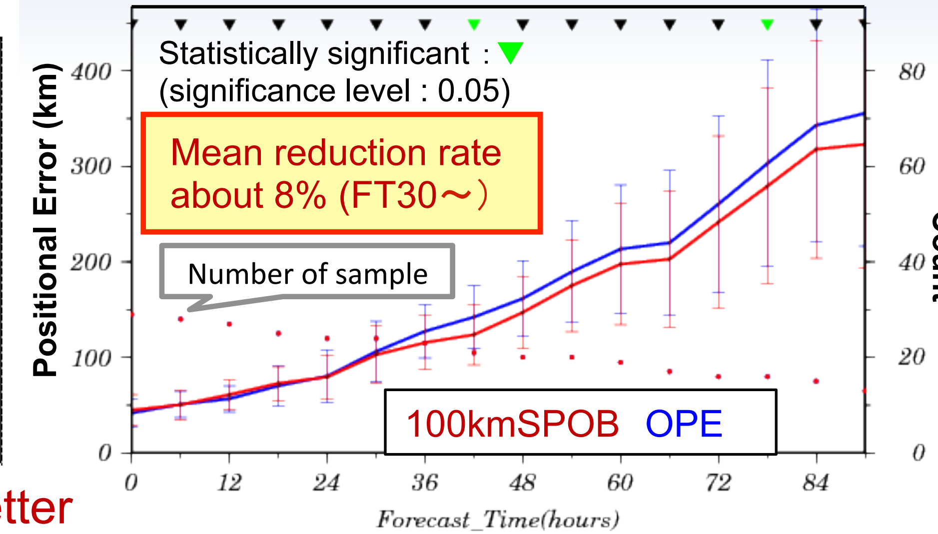
Normalized RMSE difference on v-component wind of the first-guess (solid red line) and analysis (dashed red line) fields against aircraft observation over NH

Results of OSE

Error map of 200hPa u-component wind
for 100kmSPOB against OPE



Average of typhoon positional errors

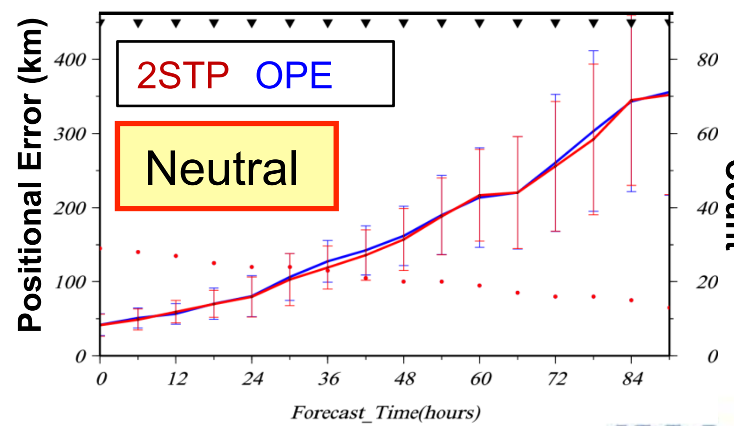


Super-observation method with RS-AMVs

Reduction of observation errors in vicinity of Japan

Improvement of mean typhoon positional errors

OPE – Without RS-AMVs



OSE FOR RS-AMVS USING MESO-SCALE NWP SYSTEM (MSM)

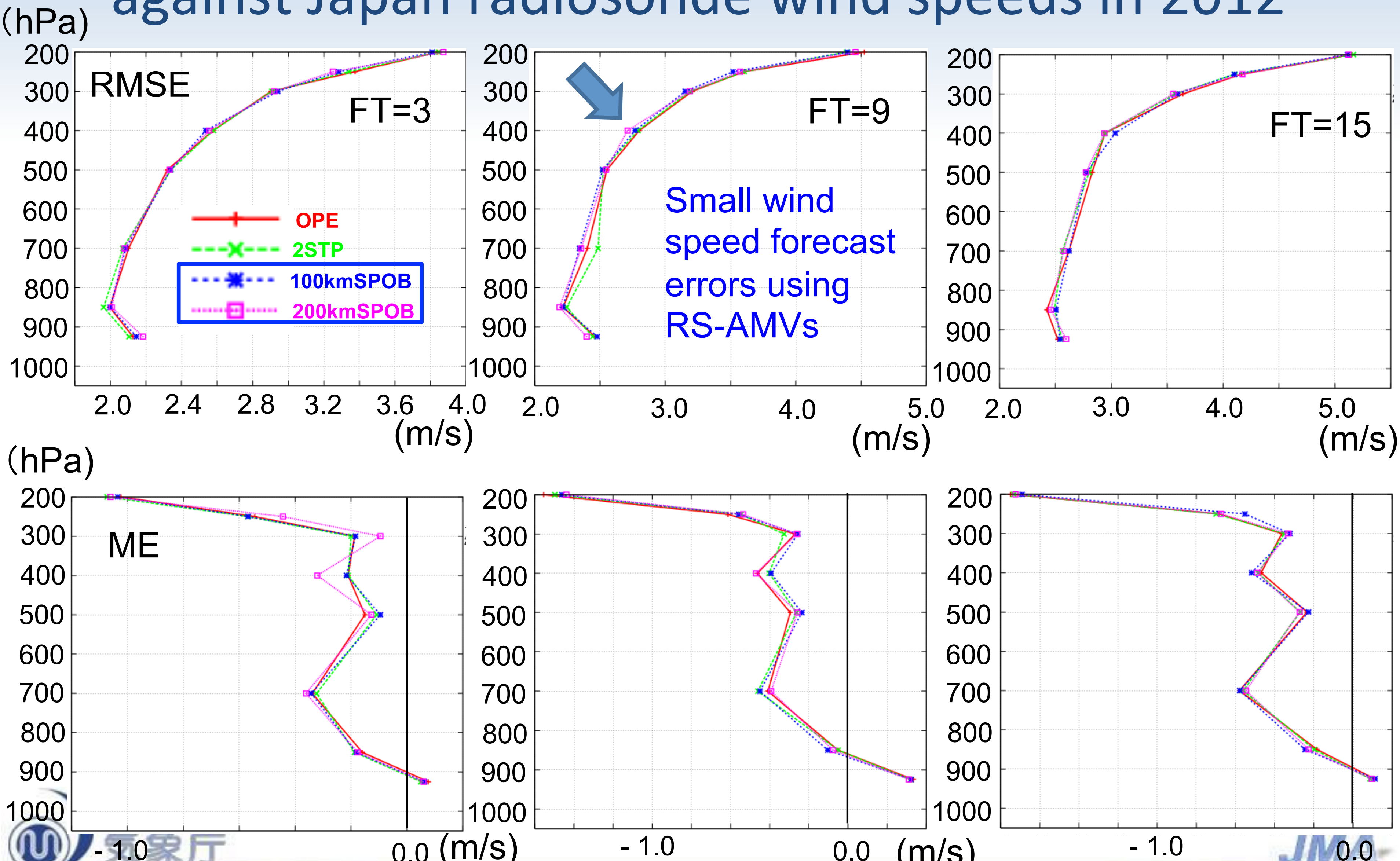
Experimental Design

Name	Specification
OPE	A scheme of the 200 km thinning of OPE-AMVs in the 3 hour time window
2STP RS-AMVs(100km thin.) OPE-AMVs(200km thin.)	2-step thinning scheme ➢ A combination scheme of the 100 km thinning of RS-AMVs in 2 hour time window and the 200 km thinning of OPE-AMVs in 3 hour time window
100kmSPOB (OPE-AMVs＋RS-AMVs)	Super-observation procedure Average of AMVs (RS-AMVs) directions and speeds with 100 km intervals in hourly time window Averaging about time, level, space, wind directions and speeds
200kmSPOB	Same as 100kmSPOB, but average of AMVs with 200 km intervals

Case study ① Typhoon MA-ON (T1106) hit Murotomisaki and heavy Rain in Niigata and Fukushima (Not shown)
② Baiu front with heavy rain

Period : Data assimilation (DA) and Forecast
① From 15 July 2011 to 31 July 2011 (17 days : Not shown)
② From 22 June 2012 to 29 July 2012 (38 days)

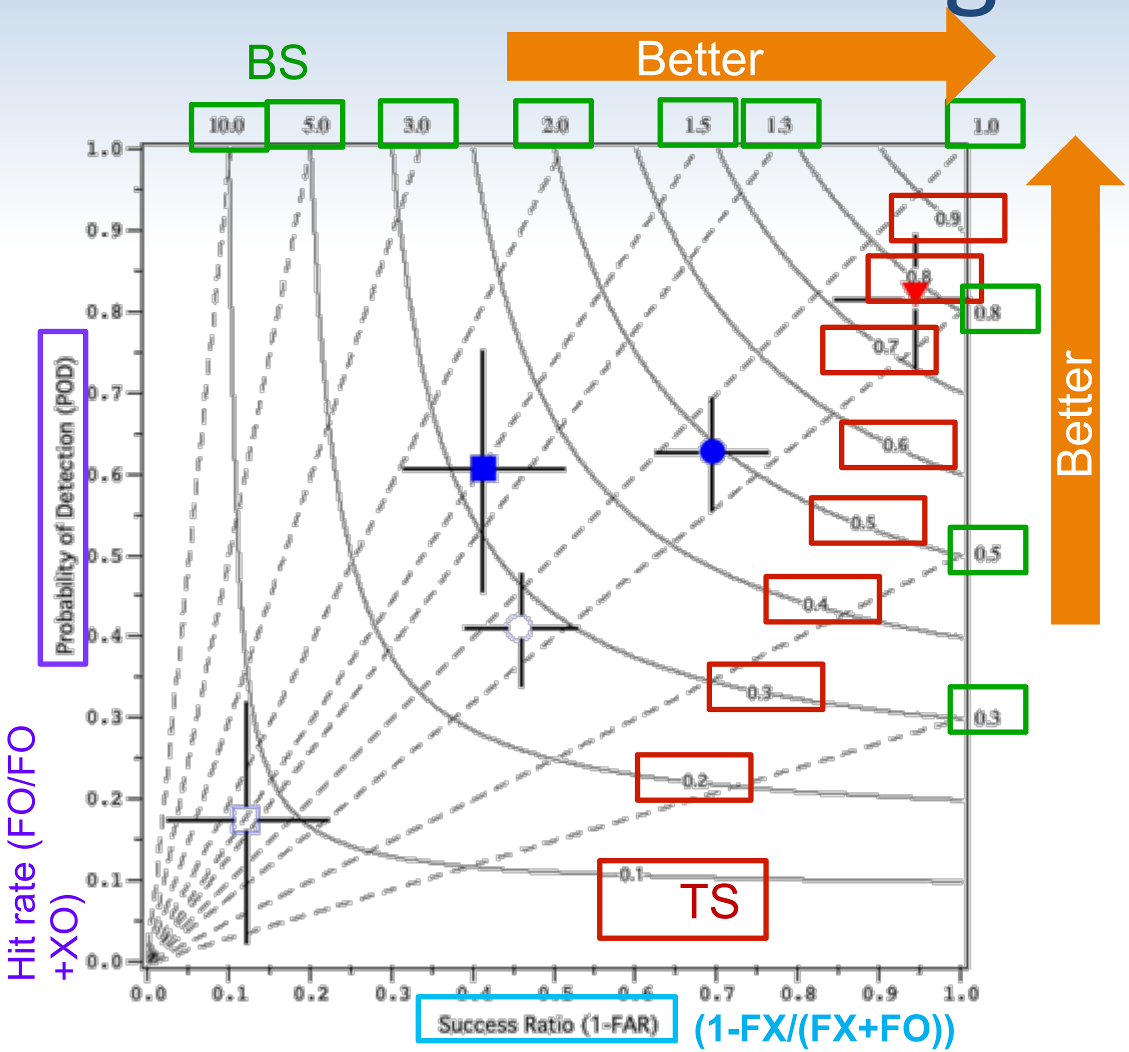
RMSE and ME of forecasts against Japan radiosonde wind speeds in 2012



FT: Forecast time

Performance diagram

	Obs. (Yes)	Obs. (No)
Fct. (Yes)	FO	FX
Fct. (No)	XO	XX



- To use a 2 x 2 contingency table which is constructed from dichotomous (yes–no) forecasts and observations
- To exploit the geometric relationship between four measures of dichotomous forecast performance:
  - Probability of detection (POD)
  - False alarm ratio or its opposite, Success ratio (SR)
  - Bias (BS)
  - Critical success index (CSI; also known as the threat score (TS))

For good forecasts, POD, SR, bias and CSI approach unity, such that a perfect forecast lies in the upper right of the diagram.

Roebber, P.J., 2009: Visualizing multiple measures of forecast quality. *Wea. Forecasting*, **24**, 601-608.

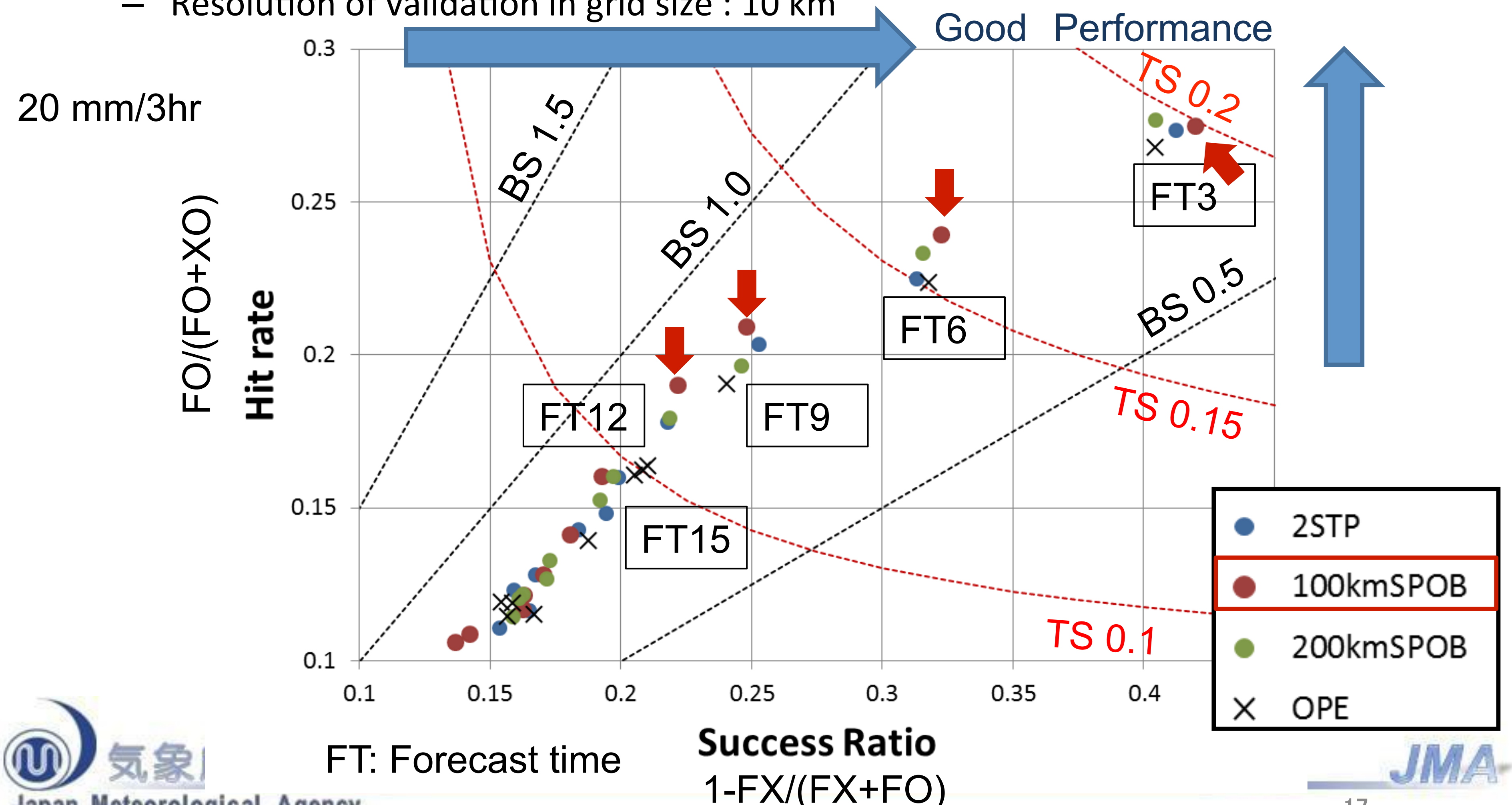
Japan

JMA

Score for Precipitation Forecasts (FT=3-39) in Japan area (Performance diagram in 2012 : ex. 20 mm/3-hour)

- Condition
  - Initial forecast time : 00,03,06,09,12,15,18 and 21 UTC
  - Resolution of validation in grid size : 10 km

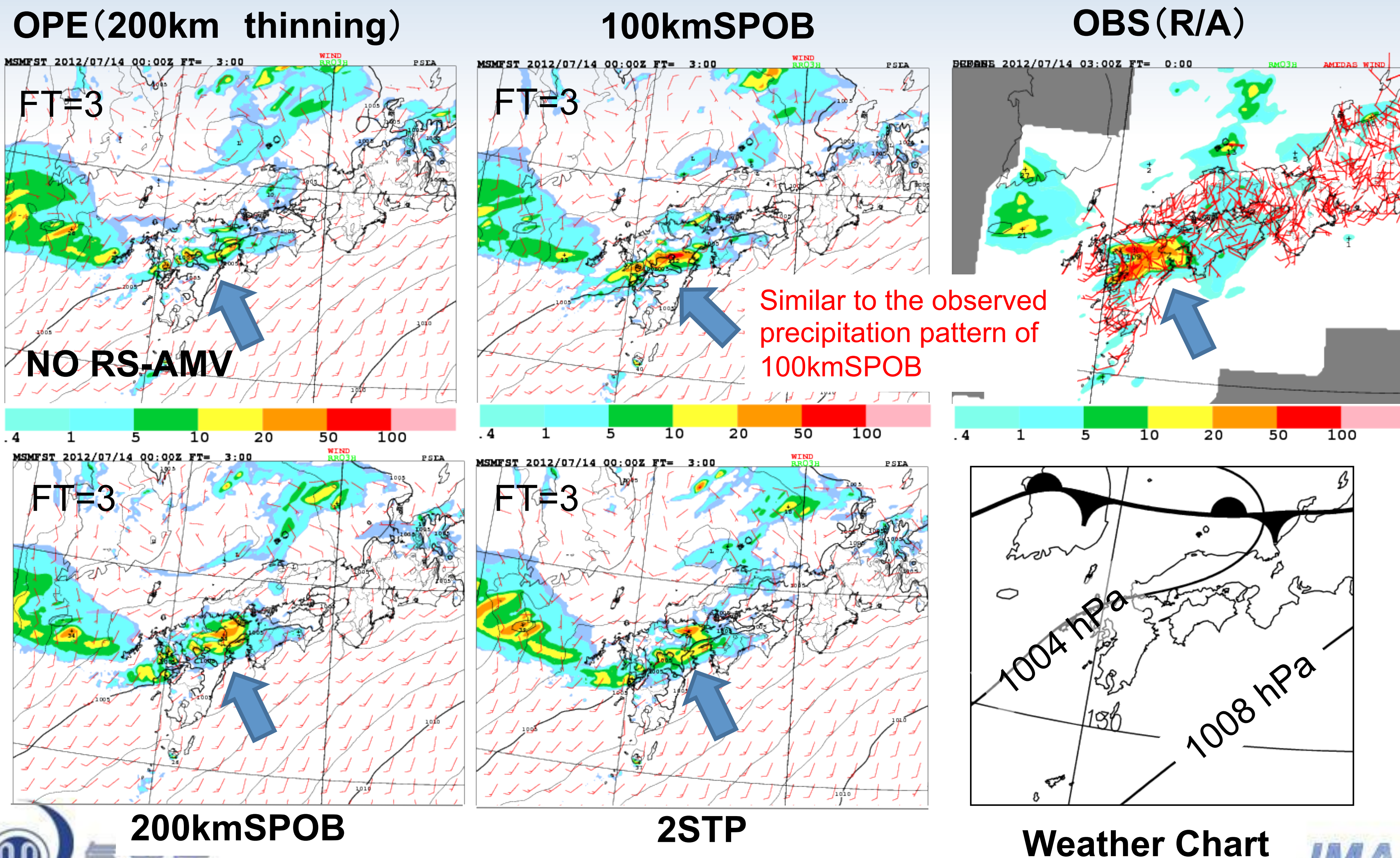
BS = (FO+FX)/(FO+XO)
TS = FO/(XO+FO+FX)



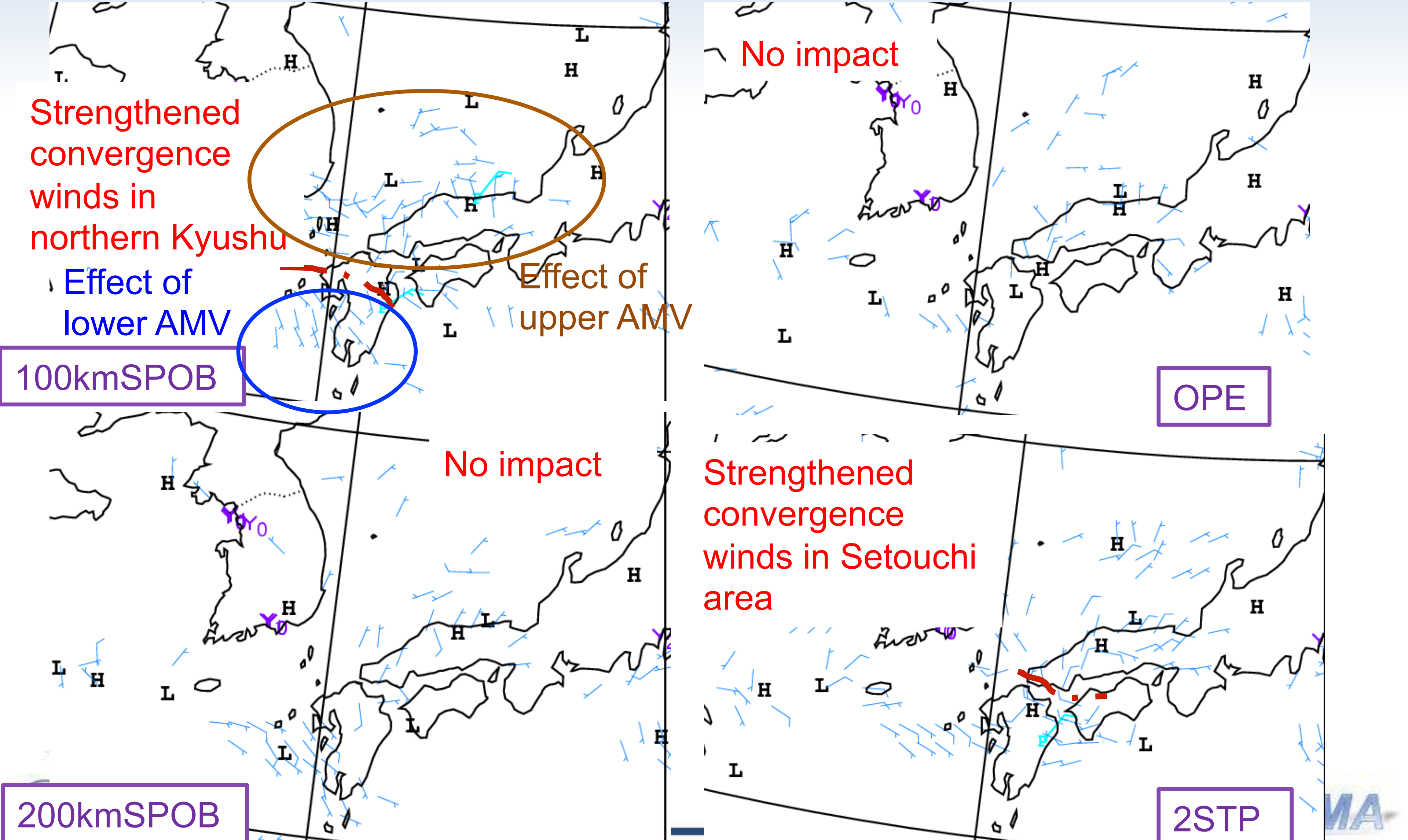
FT: Forecast time

（Roebber,2009）

Case study of Baiu front heavy rain in July 2012
（Initial forecast time : 00 UTC 14 July, 2012）



Increment of geopotential height and winds for 850 hPa at 00 UTC 14 July 2012



Summary

- OSEs of RS-AMV using the global, meso-scale and local operational NWP system from 2011 to 2013 were performed. The results showed:
  - In the global NWP system from 2 to 16 October 2013
    - Reduction of observation errors in vicinity of Japan using super-observation (SPOB) method with RS-AMVs
    - Improvement of mean typhoon positional errors
  - In the meso-scale NWP system in 2011 and 2012
    - Small wind speed forecast errors (RMSE) in almost all level in first half forecast using SPOB against sonde observations
    - Good precipitation 100kmSPOB forecasts in first half forecast (until 12-hours)
  - In the local NWP system from 00 UTC 3 to 23 UTC 12 July 2012
    - No impact for RS-AMVs
    - 3D-Var system not including the flow-dependent background error covariances
    - Good precipitation forecasts using all AMVs without thinning, but bad wind speed forecast errors (RMSE) in this case study

Future plan

- We plan to perform more OSEs for MTSAT RS-AMVs to confirm performance of procedures and to prepare for usage of the next Himawari satellites. As the 2-step thinning scheme of RS-AMVs does not bring the improvement of the analysis and forecast through the results of OSEs, we will remove the scheme.
  - Consideration of super-observation procedure in the appropriate area and grid size
    - in vicinity of Japan etc. and 100 km or 200 km etc.


THANK YOU FOR YOUR ATTENTION

BACK UP

OSE FOR RS-AMVS USING MESO-SCALE NWP SYSTEM (MSM)

Experimental Design

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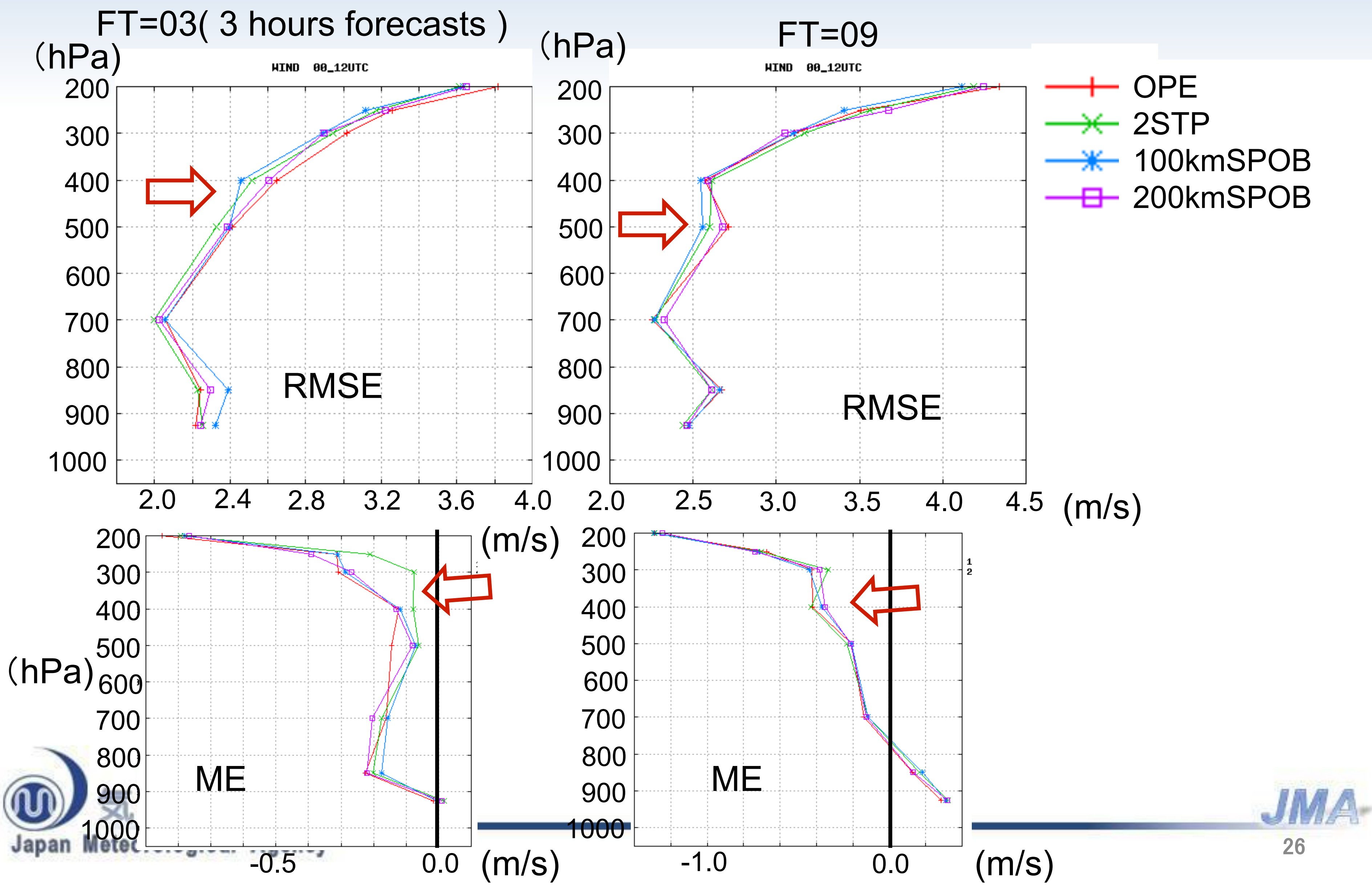
② Baiu front with heavy rain

Period : Data assimilation (DA) and Forecast
① From 00UTC 15 July 2011 to 21UTC 31 July 2011 (Not shown)
② From 00UTC 22 June 2012 to 21UTC 29 July 2012

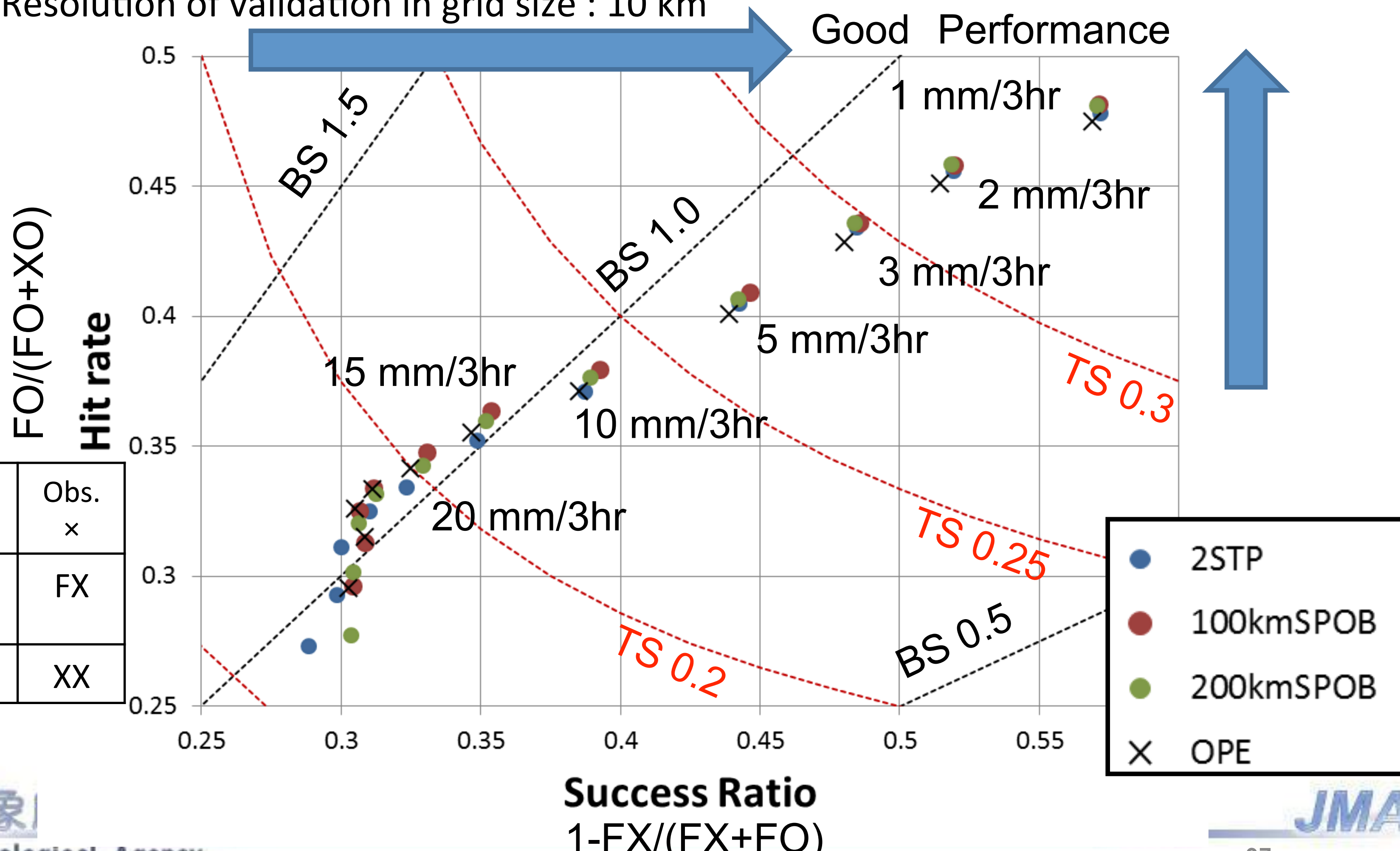
RMSE and ME of forecasts against Japan radiosonde wind speeds in 2011



Score for Precipitation Forecasts (FT=3-33) in Japan
～Performance diagram in 2011 ～

- Condition
  - Initial forecast time : 03,09,15 and 21 UTC
  - Resolution of validation in grid size : 10 km

BS = (FO+FX)/(FO+XO)
TS = FO/(XO+FO+FX)



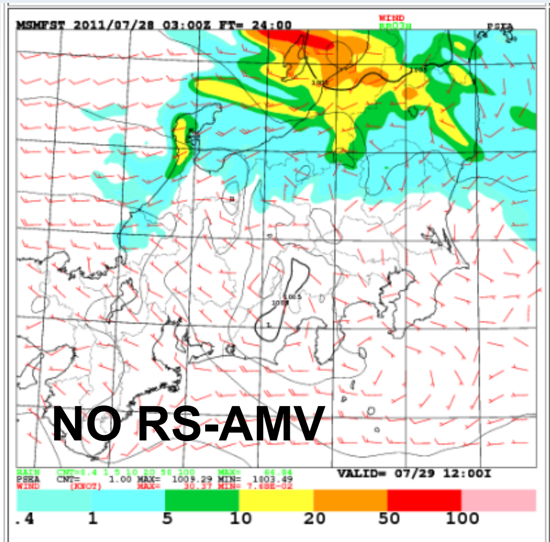
	Obs. ○	Obs. ×
Fct. ○	FO	FX
Fct. ×	XO	XX

(Roebber,2009)

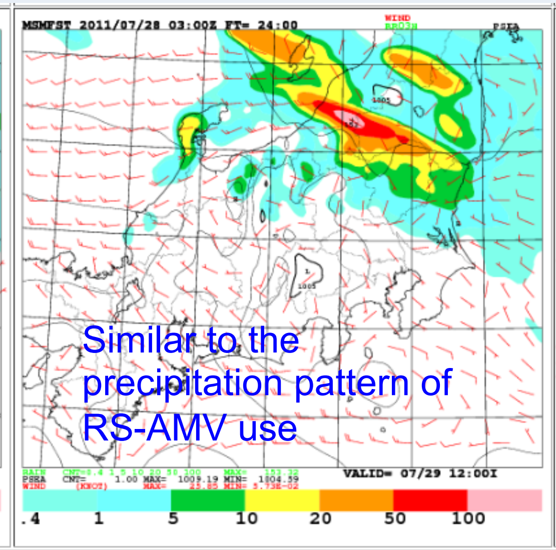
Case study of Niigata and Fukushima heavy rain in July 2011
（Initial forecast time : 03 UTC 28 July, 2011）

FT=24

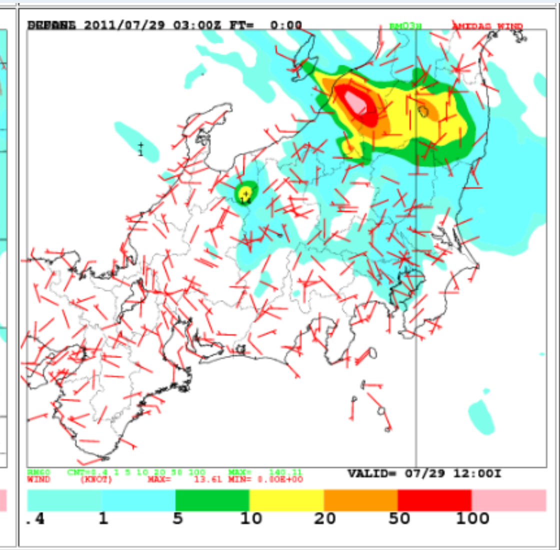
OPE（200km thinning）



100kmSPOB

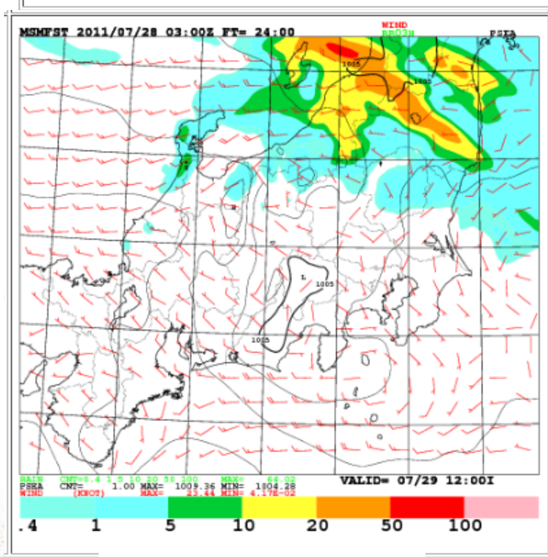


OBS（R/A）

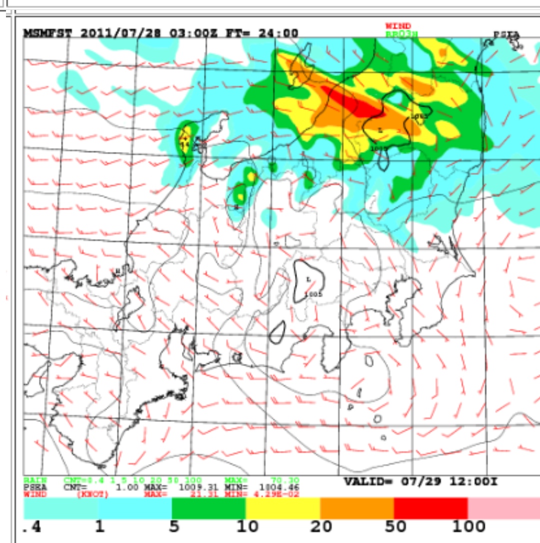


FT=24

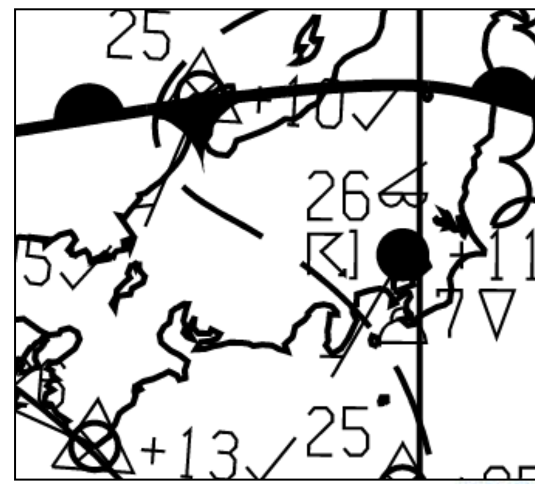
200kmSPOB



2STP

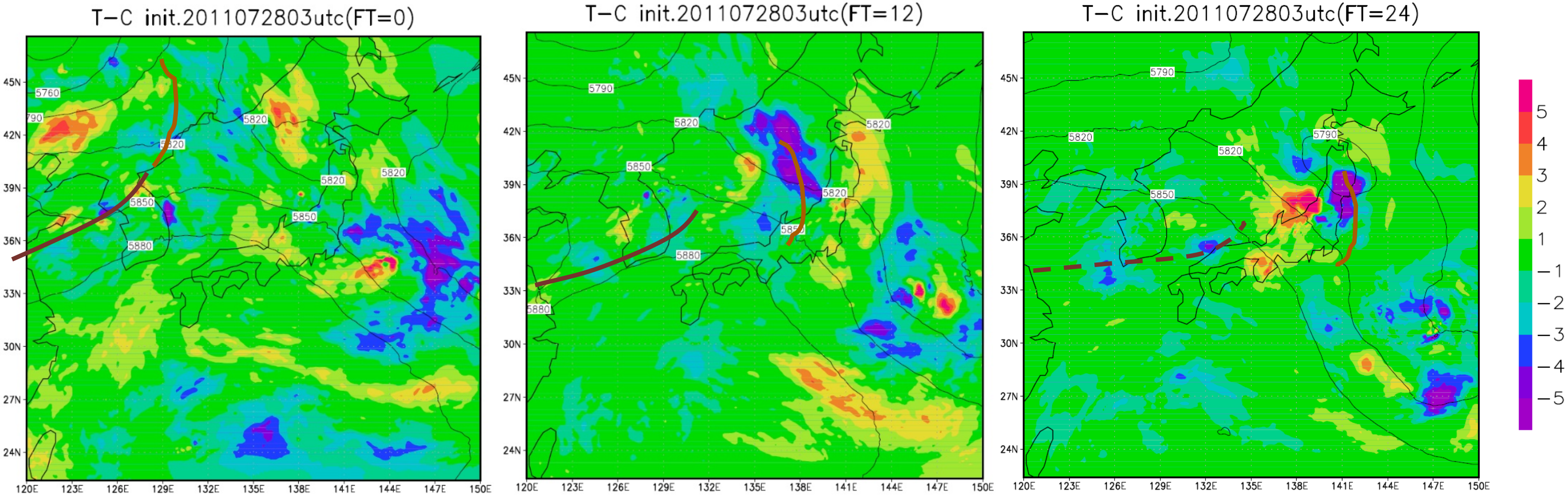


Weather Chart



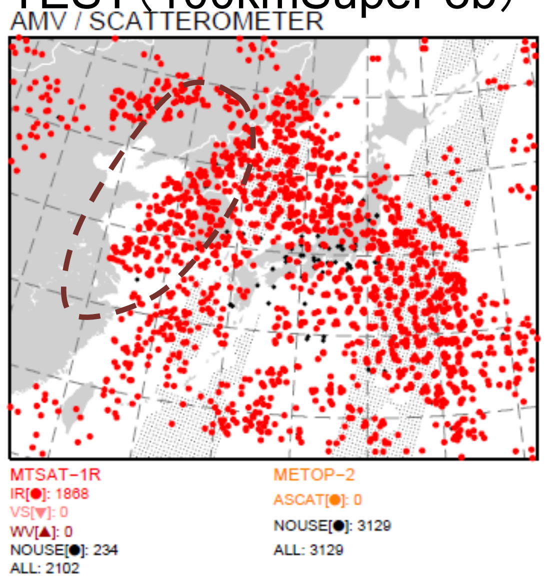
Difference between TEST(100kmSuper-ob) and CNTL(OPE) of T+0,12,24 forecasts for 500 hPa Geopotential Height (m)

（Initial forecast time : 03 UTC 28 July, 2011）

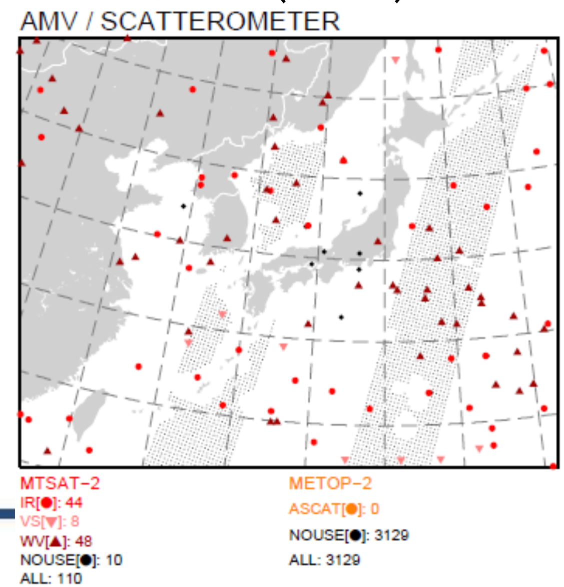


Coverage for AMV

TEST（100kmSuper-ob）



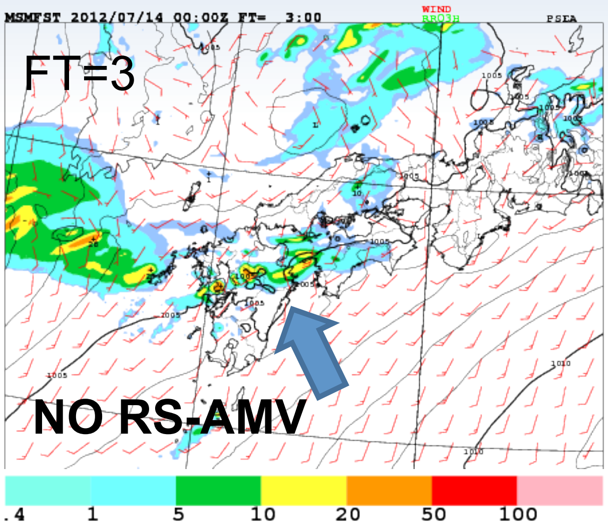
CNTL（OPE）



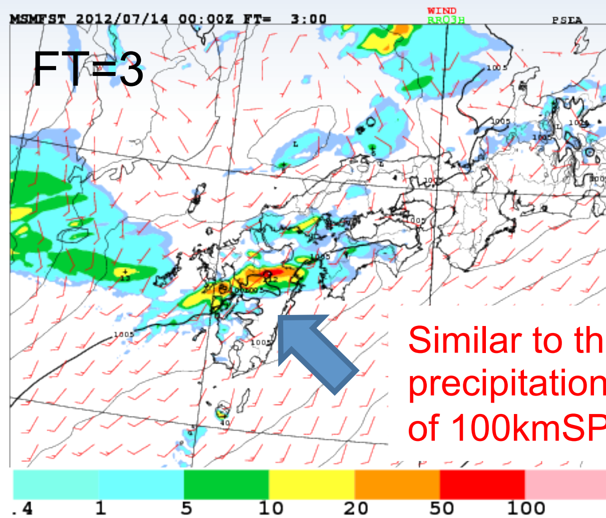
気象庁
Japan Meteorological Agency

Case study of Baiu front heavy rain in July 2012
（Initial forecast time : 00 UTC 14 July, 2012）

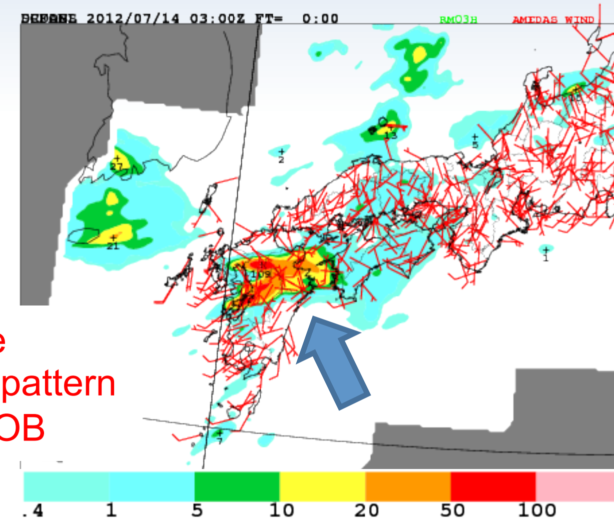
OPE（200km thinning）



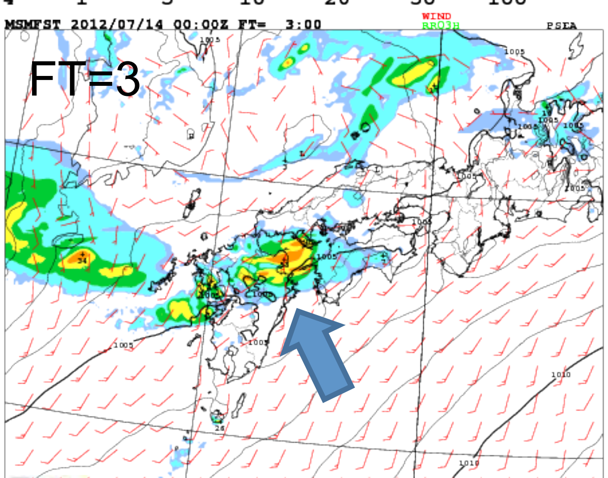
100kmSPOB



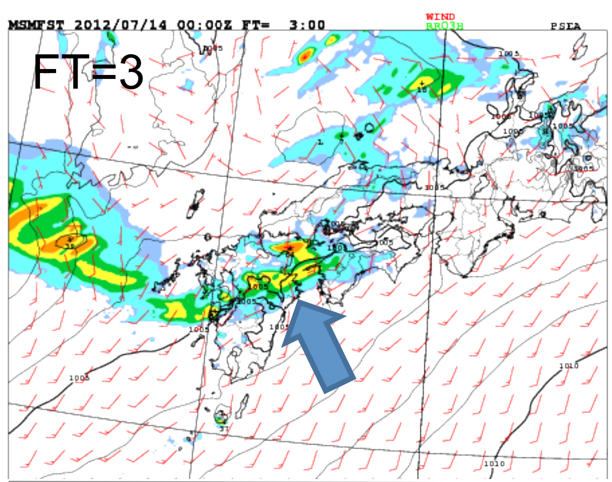
OBS（R/A）



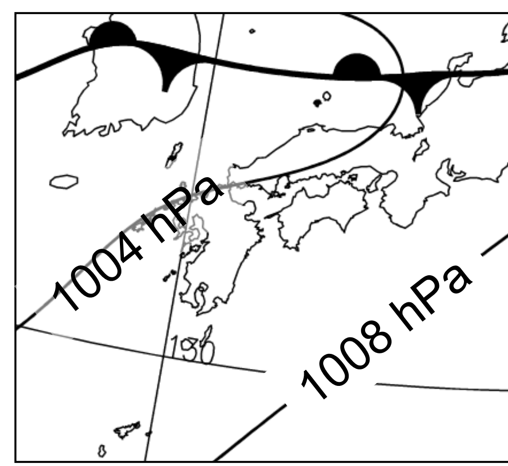
Similar to the precipitation pattern of 100kmSPOB



200kmSPOB

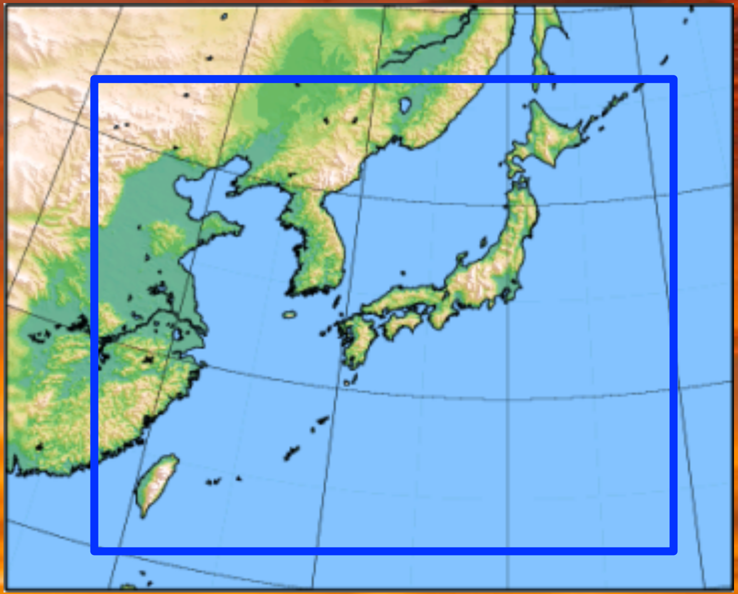


2STP



Weather Chart

OSE FOR RS-AMVS USING LOCAL NWP SYSTEM

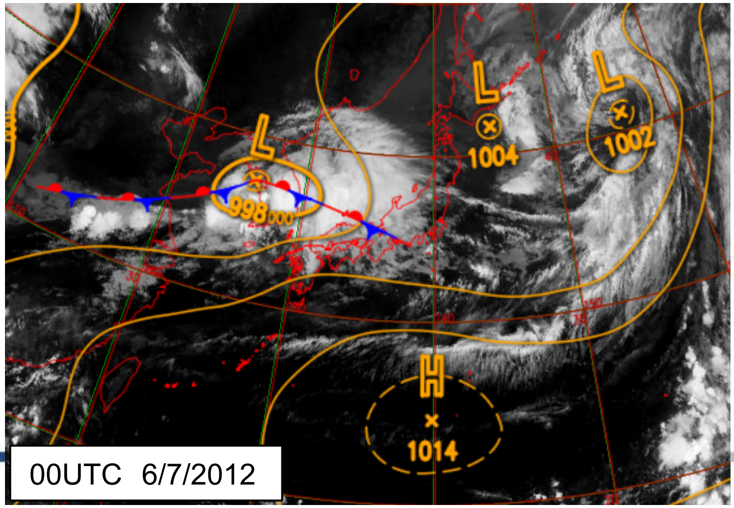


Experimental Design

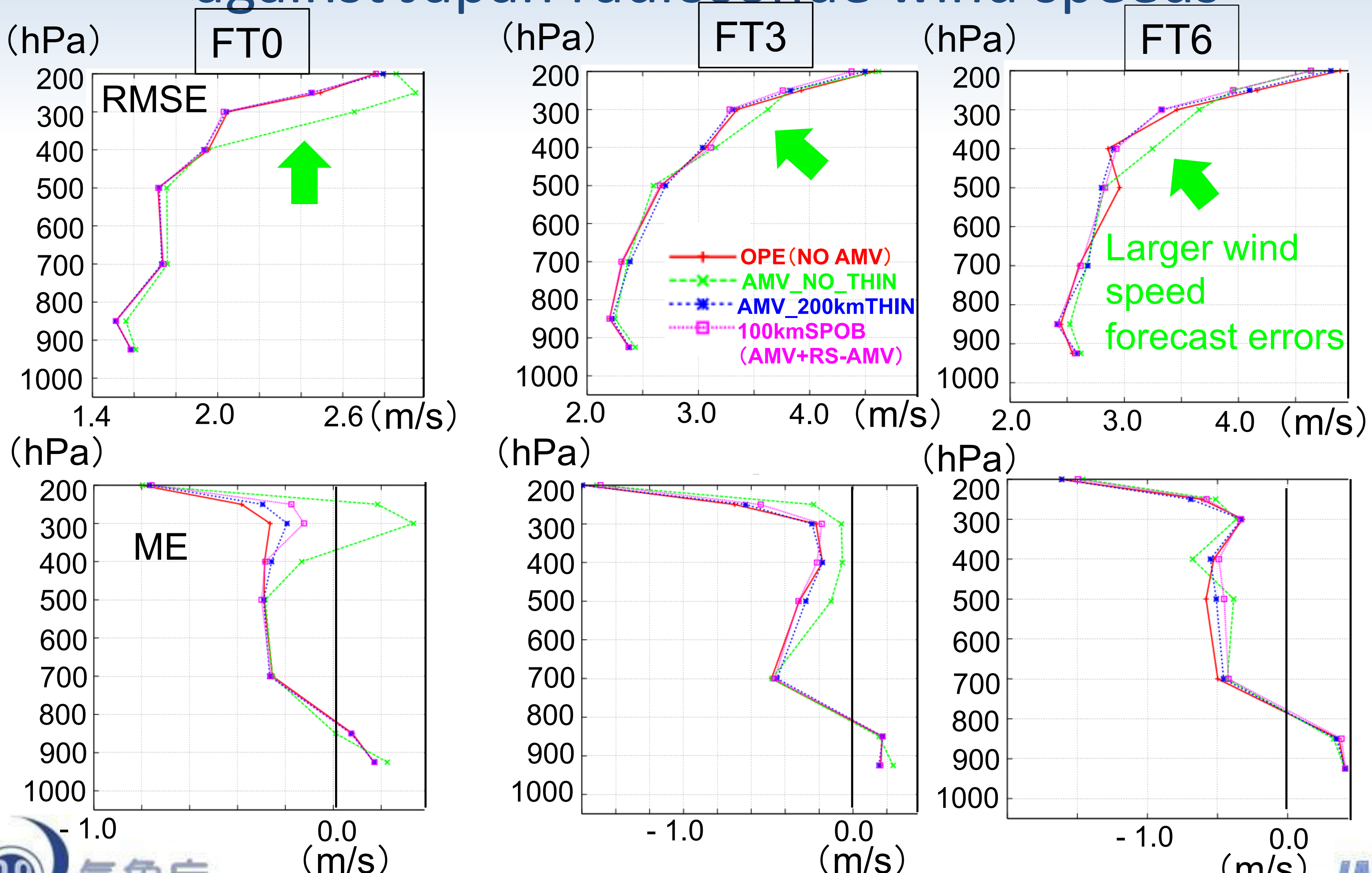
Name	Specification
OPE	Not used all AMVs
AMV_NO_THIN	Used AMVs (QI>=60: Not used RS-AMVs)
AMV_200kmTHIN	A scheme of the 200 km thinning of RTN-AMVs in the 3 hour time window (QI >= about 84: Not used RS-AMVs)
100kmSPOB（AMV＋RS-AMV）	Super-observation procedure (QI >= about 86） Average of AMVs (RS-AMVs) directions and speeds with 100 km intervals in hourly time window Averaging about time, level, space, wind directions and speeds

- Period: Assimilation and Forecast : From 00 UTC 3 to 23 UTC 12 July 2012

Case study of Baiu front with heavy rain



RMSE and ME of forecasts against Japan radiosonde wind speeds

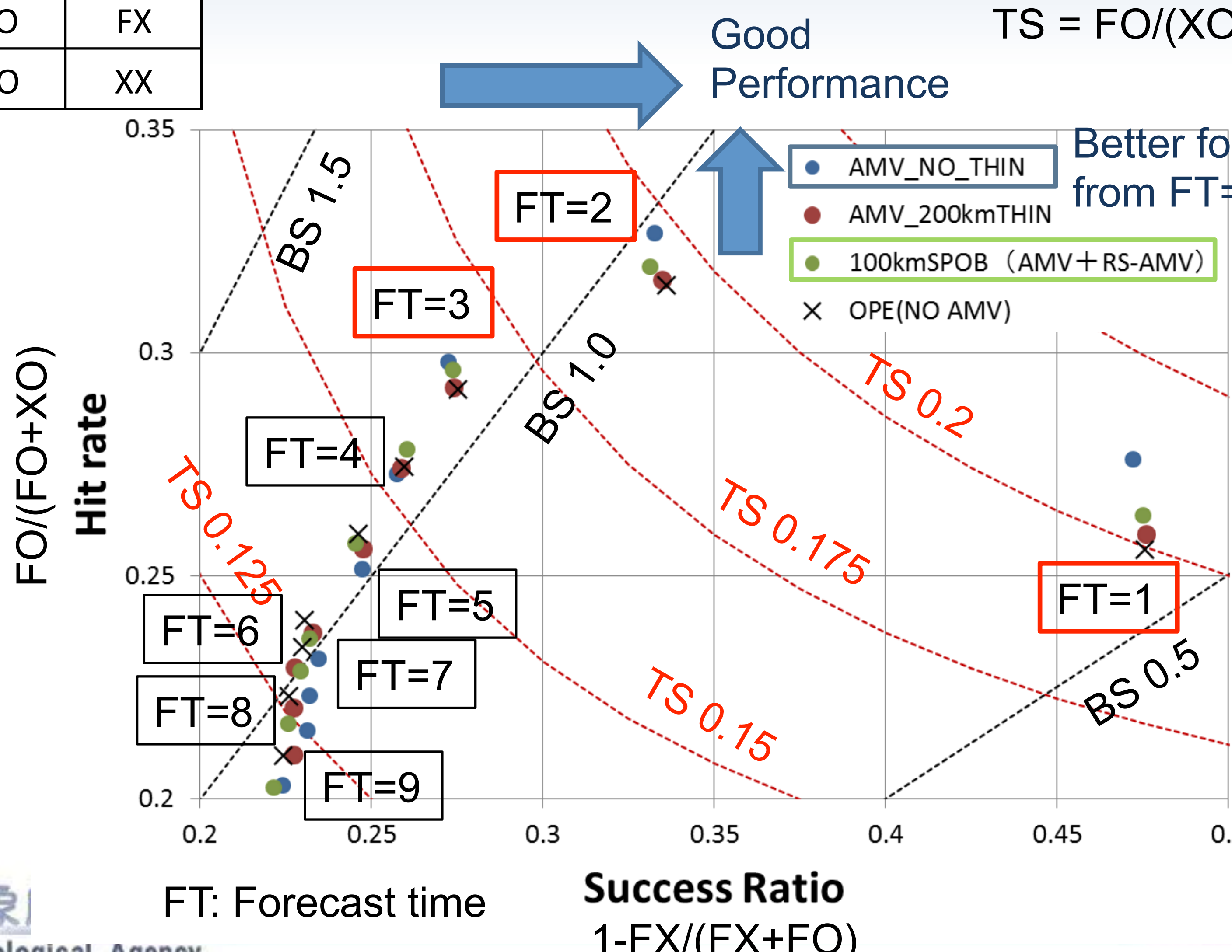


Score for Precipitation Forecast in Japan area
Performance diagram（TS/BS：5mm/h）

	Obs. ○	Obs. ×
Fct. ○	FO	FX
Fct. ×	XO	XX

BS = (FO+FX)/(FO+XO)
TS = FO/(XO+FO+FX)

Better forecasts from FT=1 to 3



FT: Forecast time

（Roebber,2009）

DIFFERENCE OF FORECAST ACCURACY BY MTSAT AMVS GENERATED FROM 5,10,15 OR 30 MINUTES INTERVAL RAPID SCAN IMAGES USING THE GLOBAL (GSM) AND MESO-SCALE NWP SYSTEM (MSM)

Purpose

- To find an optimum AMV in high resolution NWP system
  - What should be the method for evaluation ?
    - Analysis fields
      - First-guess departure (O-B) statistics for AMVs
    - Forecast fields
      - RMSE and ME of forecasts against sonde observations and the others
      - Precipitation forecast
      - Tropical Cyclone positional errors etc.
  - We tried to investigation about red color characters previously-shown.

Verification and Experimental design

- Verification of AMVs from rapid scan images in first-guess departure (O-B) statistics for AMVs
  - Target : AMVs generated from 5,10,15 or 30 minutes interval rapid scan images
  - Region : 20N-45N and 120E-150E (Japan area)
  - Using the global NWP system (GSM)
- Experimental design of OSE
  - Target : AMVs generated from 5,10 or 30 minutes interval rapid scan images
  - Period : From 22 June 2012 to 29 July 2012 (38 days)
  - AMV usage : 100 and 200 km Super-observation procedure

  (hereafter as 100kmSPOB and 200kmSPOB respectively)

Verification of AMVs in 20N-45N and 120E-150E (Japan area)

- Wind speeds of AMVs with the intervals of 10, 15 or 30 minutes (hereafter as 10minAMV, 15minAMV or 30minAMV respectively) from rapid scan observations were compared to AMVs with 5 minutes (5minAMV) in GSM (Grid size : 20 km) first-guess departure (O-B) statistics.

	IR-HL			IR-ML			IR-LL		
	Count	ME (m/s)	STD (m/s)	Count	ME (m/s)	STD (m/s)	Count	ME (m/s)	STD (m/s)
5minAMV	3230117	-0.07	3.33	312655	0.13	3.12	553995	0.00	2.21
10minAMV	3090353	0.06	3.19	240099	0.26	2.94	601716	0.16	2.07
15minAMV	2798467	0.13	3.15	213889	0.35	2.90	499449	0.21	2.00
30minAMV	1806637	0.28	3.09	92249	0.46	2.83	314610	0.22	1.86

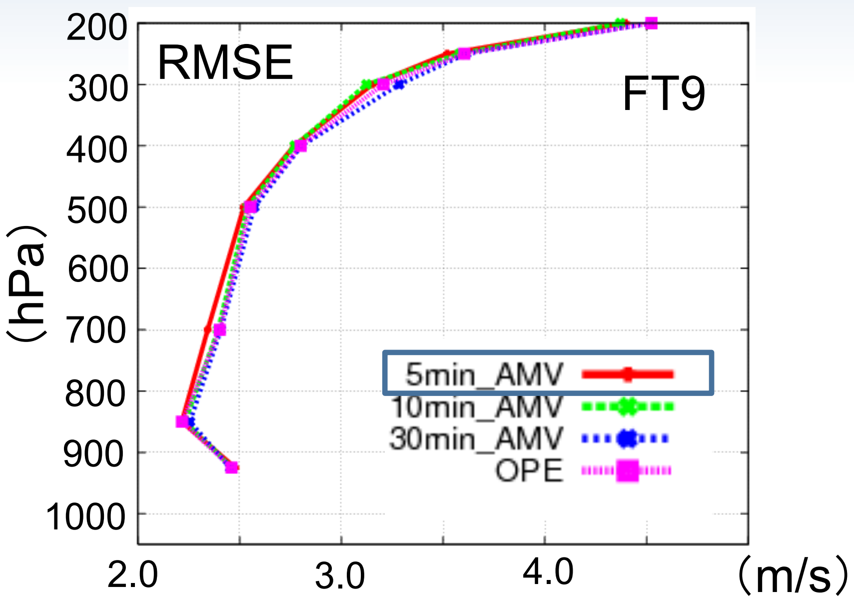
	WV-HL		
	Count	ME (m/s)	STD (m/s)
5minAMV	4516768	0.79	3.37
10minAMV	4905081	0.88	3.23
15minAMV	4520636	0.89	3.20
30minAMV	3244380	0.90	3.14

IR: infrared sensor
VS: visible sensor
WV: water vapor
HL: 0-400 hPa
ML: 400-700 hPa
LL: 700-1000 hPa

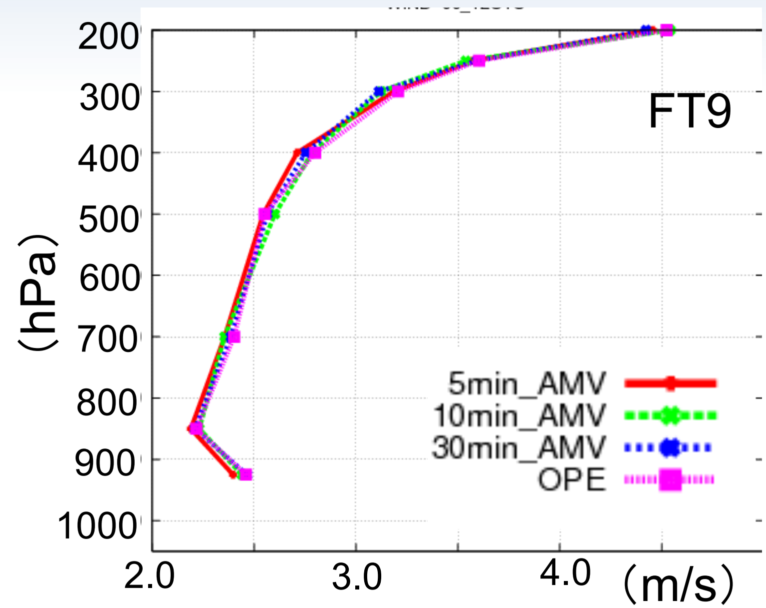
	VS-LL		
	Count	ME (m/s)	STD (m/s)
5minAMV	588914	0.42	2.04
10minAMV	541308	0.39	1.93
15minAMV	419253	0.38	1.89
30minAMV	215226	0.39	1.75

Standard Deviation (STD) < 30minAMV < 15minAMV < 10minAMV< 5minAMV

RMSE of forecasts against Japan radiosonde wind speeds (ex. FT=9)



5kmMSM+100kmSPOB

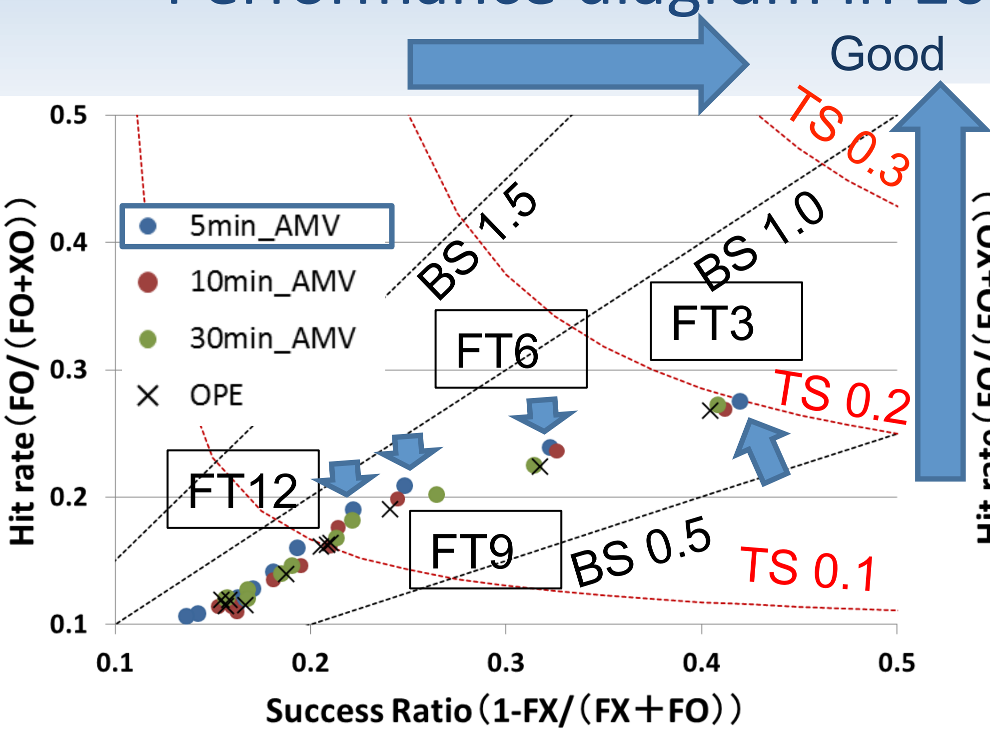


5kmMSM+200kmSPOB

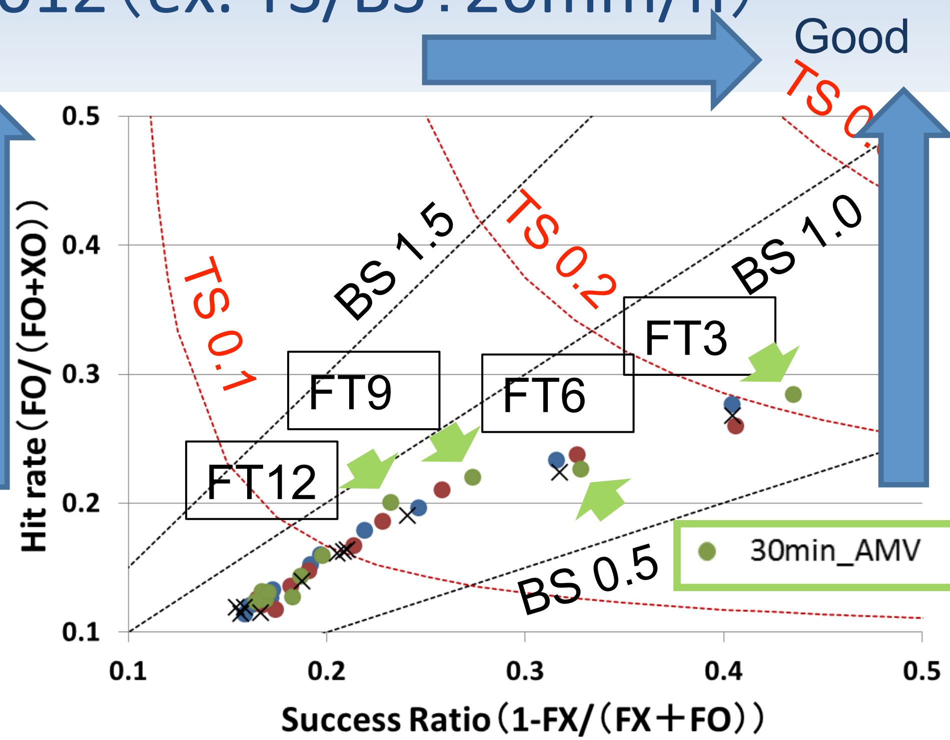
Smallest wind speed forecast errors (RMSE) above 850 hPa in 5minAMV until 9-hours

No impact wind speed forecasts errors

Score for Precipitation Forecast in Japan
Performance diagram in 2012（ex. TS/BS：20mm/h）



5kmMSM+100kmSPOB



5kmMSM+200kmSPOB

Best precipitation forecasts in first half forecast (until 12-hours) using 5minAMV

Best precipitation forecasts in first half forecast (until 12-hours) using 30minAMV

Summary (2/2)

- Difference of forecast accuracy by MTSAT AMVs generated from 5,10,30 minutes interval images using the global and Meso-scale NWP system from 00UTC 22 June 2012 to 21UTC 29 July 2012

  The results showed:

  – 20kmGSM O-B statistics
    - Small STD in the order of AMVs from longest time to shortest time interval images

  Standard Deviation (STD) < 30minAMV < 15minAMV < 10minAMV< 5minAMV

  – 100kmSPOB method
    - Best precipitation forecasts in first half forecast (until 12-hours) using AMV with the interval images of 5 minutes (5minAMV)

  – 200kmSPOB method
    - Best precipitation forecasts in first half forecast (until 12-hours) using 30minAMV

  – Maybe holding forecast accuracy relationship between usage of AMVs (grid size etc.) and the interval of satellite images of AMVs by results of precipitation forecasts

Future plan

- We plan to perform more OSEs for MTSAT RS-AMVs to confirm performance of procedures and to prepare for usage of the next Himawari satellites. As the 2-step thinning scheme of RS-AMVs does not bring the improvement of the analysis and forecast through the results of OSEs, we will remove the scheme.
  - Consideration of super-observation procedure in the appropriate area and grid size
    - in vicinity of Japan etc. and 100 km or 200 km etc.
- I'm investigating difference of forecast accuracy by MTSAT AMVs generated from 5,10,30 minutes interval images using the global and Meso-scale NWP system.
- To find an optimum AMV in high resolution NWP system, we plan to perform more OSEs to clarify the forecast accuracy relationship between usage of AMVs and the interval of satellite images of AMVs.