Assimilation of Himawari-8 Atmospheric Motion Vectors into the Numerical Weather Prediction Systems of Japan Meteorological Agency

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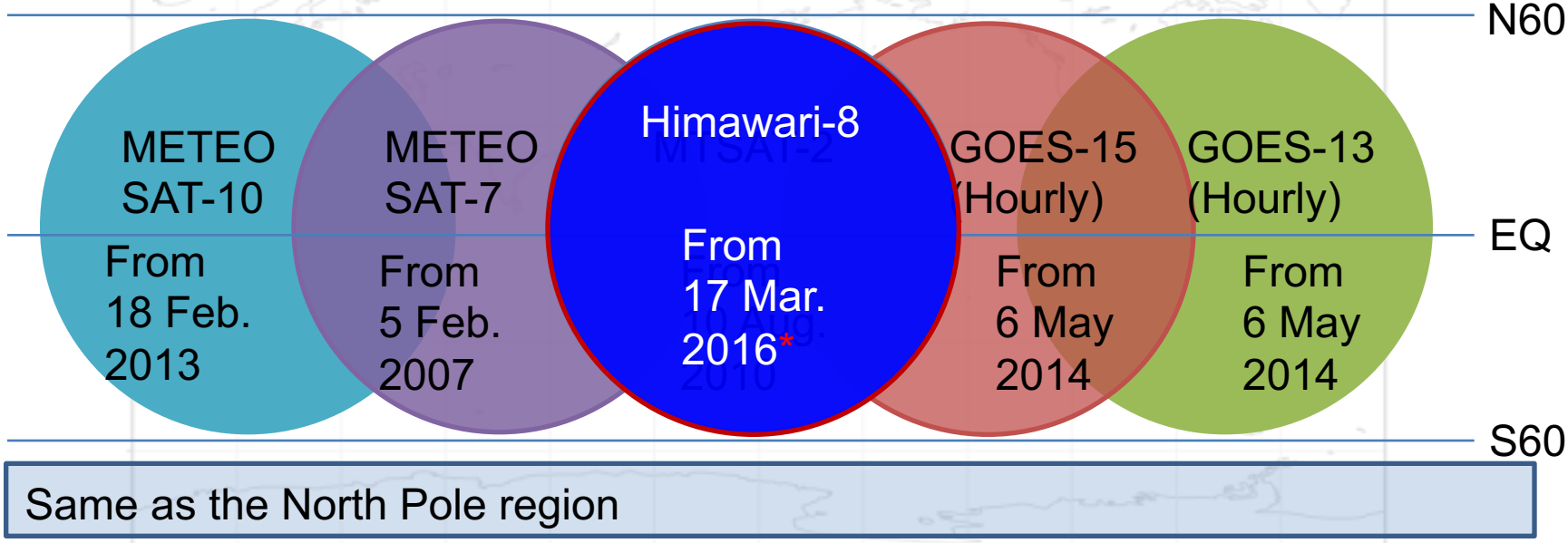
Operational AMVs (OPE-AMVs) Satellite Status update for NWP use in JMA

NESDIS and CIMSS MODIS polar winds (Terra and Aqua) from 28 May 2004
AVHRR polar winds from 1 Jul. 2013
LEO-GEO winds from 1 Jul. 2013



Same as the North Pole region

Himawari-8 AMVs have also assimilated into JMA's operational regional NWP Systems as same method except Super-observation scheme as the operational global NWP Systems since 17 March 2016.

* K.Yamashta 2016: Assimilation of Himawari-8 atmospheric motion vectors into JMA's operational global, mesoscale and local NWP systems. CAS/JSC WGNE Res. Activ. Atmos. Oceanic Model, Submitted.

TODAY'S TALK

Assimilation of Himawari-8 AMVs into the operational global NWP System of JMA

Hereafter the items associated with regional NWP Systems are abbreviated.
（The impacts for regional NWP system will be presented by Michiko Otsuka and Kenichi Nonaka in presentations tomorrow.）

Outline

- Background
- Purpose
- NWP system for Observing System Experiment (OSE)
- Characteristics of Himawari-8 AMVs
- Quality control
- OSE results
- Summary and future plans

Background

- The Meteorological Satellite Center of JMA started production of Himawari-8 AMVs on July 7th, 2015.
  - The AMVs are being produced using three sequential Himawari-8 images with 10 minutes interval.
- It was reported that the quality of the Himawari-8 AMVs has been improved by employing new tracking and new height assignment algorithms.

  (Presented by Kazuki Shimoji in presentations yesterday)

Purpose

- To start assimilating Himawari-8 AMVs in JMA's operational NWP Systems with maximizing its impact
- For this purpose,
  - It needs to review the quality of Himawari-8 AMVs by comparing with MTSAT-2 AMVs in detail.
    - Characteristics of Himawari-8 AMV
  - And it needs to revise the quality control (QC) suitable for the Himawari-8 AMVs.

NWP SYSTEM FOR OSE

NWP system for OSE

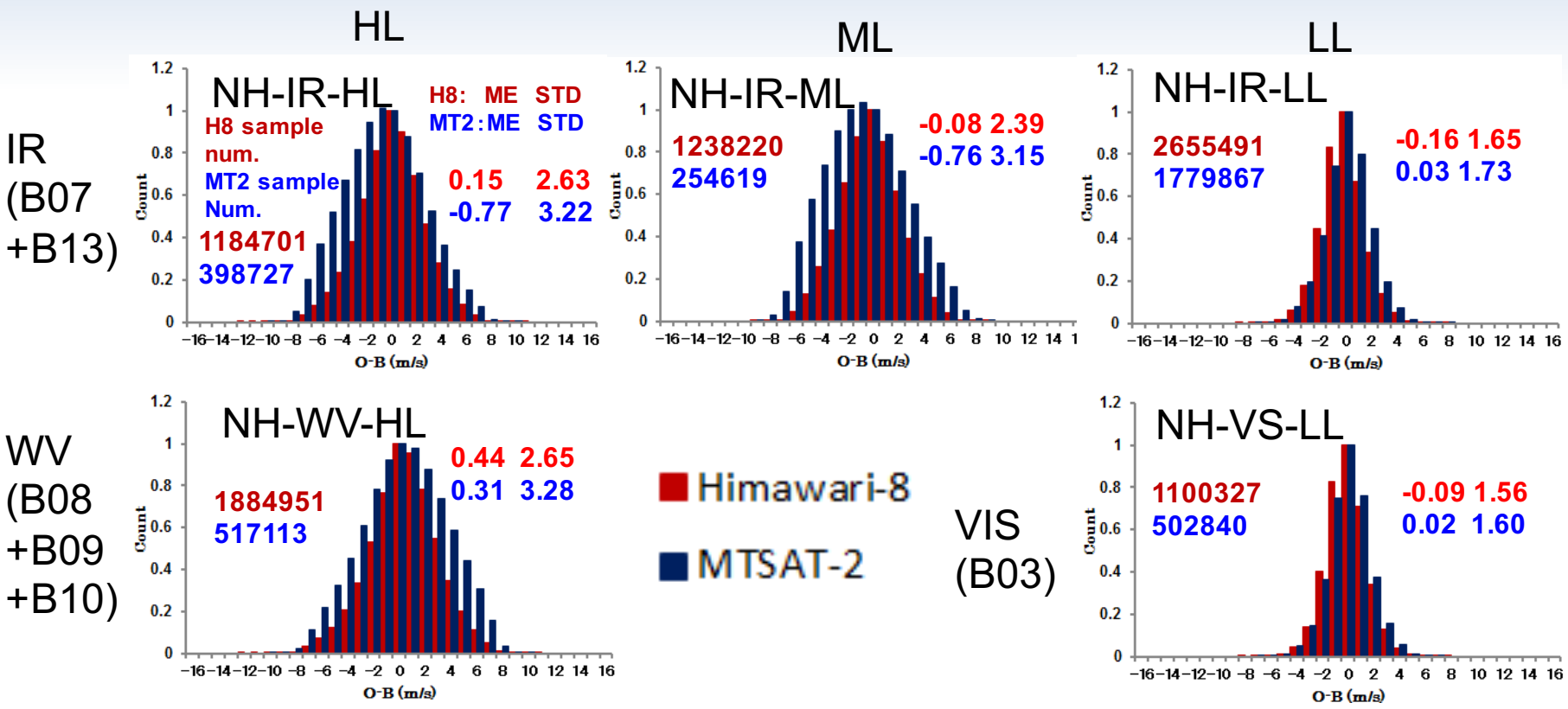
	Global (GSM-DA)
Purposes	Short- and medium-range forecasts
Forecast domain	Globe
Grid size	20 km
Vertical levels/Top	100/0.01 hPa
Forecast range (Initial time)	84 hours (00, 06, 18 UTC) 264 hours (12 UTC)
Initial condition	4D-Var Analysis
Time window	6-hour
Inner-loop model res.	55 km

CHARACTERISTICS OF HIMAWARI-8 AMVS

Characteristics of Himawari-8 AMV

- Evaluated statistically against the first guesses of the GSM-DA
- Compared with MTSAT-2 AMVs
- Conditions
  - Over 60 Quality Indicator (QI) with forecast
  - Period: From 5 February to 20 March 2015
  - Investigation items
    - Histograms of the normalized difference (O-B) between the relevant wind speeds and first guesses
- Results
  - Proper Gaussian distributions in data assimilation
  - Better accuracy Himawari-8 AMVs comparing to MTSAT-2 AMVs

O-B normalized histograms of Himawari-8 AMVs in the Northern Hemisphere (poleward of 20N)



ME: Mean Error (unit m/s)
STD: Standard Deviation (unit m/s)

HL : ≦400 hPa
ML : 400～700 hPa
LL : ≧700 hPa

O-B normalized histograms for other regions has the same characteristics.

QUALITY CONTROL (QC)

QC for Himawari-8 AMVs

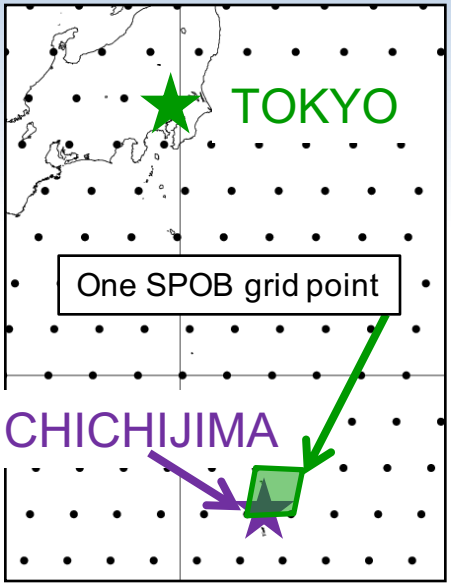
- To support the effective use of Himawari-8 AMVs, the AMV pre-processing system was updated in three main ways.
  - Revised quality indicator (QI, Holmlund 1998) with forecast thresholds for low-quality AMV rejection
  - Revised climatological checking
    - Rejection of IR and VIS AMVs over land below 700 hPa
    - Use of AMVs in the middle troposphere (utilization limitation release)
  - Introduced a 100-km super-observation technique for Japan and the surrounding areas into the global NWP system (introduced a 200-km thinning scheme for the other regions)
- Details of other QC measures are provided on the NWP SAF AMV monitoring page*.

*http://nwpsaf.eu/monitoring/amv/amvusage/jmamodel.html

Super-observation (SPOB) technique

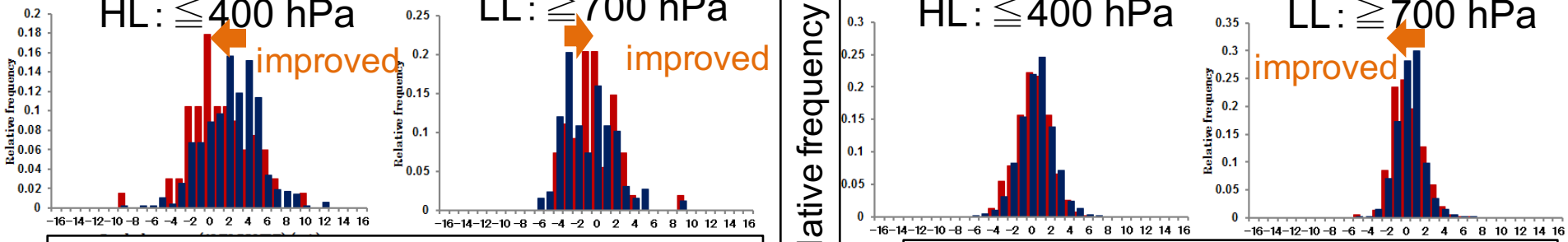
- Purpose
  - Prevention of observed information loss of many AMVs by thinning
  - Reduction of both observation errors and first guess errors
  - Improvement of mean typhoon positional errors
    - Improvement of typhoon track forecasts by OSEs for MTSAT RS-AMVs with SPOB in 2013 and 2014 (Yamashita 2014, IWW12)
- Method
  - Averaging of AMVs (observation time, level, space, wind directions and speeds) by 100 km x 100 km x 100 hPa (defined as 100kmSPOB) intervals in each hourly time window in assimilation for Japan and the surrounding areas (20N to 45N and 120E to 150E)

Verifications of SPOB technique



- Using MTSAT-1R Rapid Scan AMVs from Oct. 1 to Oct. 30, 2014
- Targeted for a 100kmSPOB grid point around CHICHIJIMA
- Investigation items
  - Histogram of the normalized difference between wind speeds and CHICHIJIMA Sonde Observations or first guesses
  - Compared with SPOB AMVs and all sensors AMVs

■SPOB AMVs after QC ■All sensors AMVs after QC



	NUM.	AV. (m/s)	STD. (m/s)
SPOB	67	1.29	3.27
ALL	474	2.28	3.01

	NUM.	AV. (m/s)	STD. (m/s)
SPOB	54	-0.21	2.38
ALL	257	-0.92	2.71

	NUM.	AV. (m/s)	STD. (m/s)
SPOB	396	0.38	1.75
ALL	3934	0.44	1.77

	NUM.	AV. (m/s)	STD. (m/s)
SPOB	384	0.32	1.61
ALL	2083	0.33	1.40

- Improved Gaussian distribution
- Almost reduction of AMV-SONDE and O-B wind speed differences

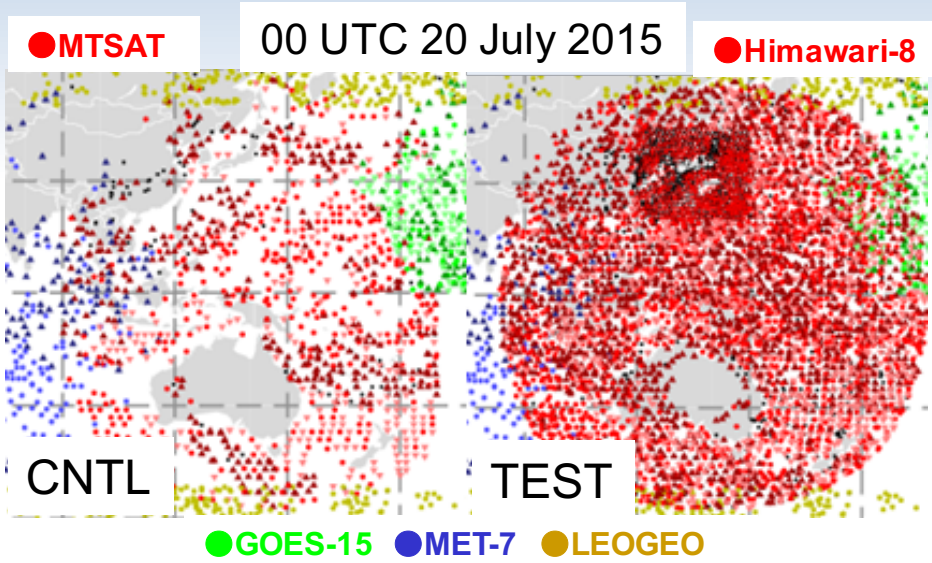
OSE FOR HIMAWARI-8 AMV

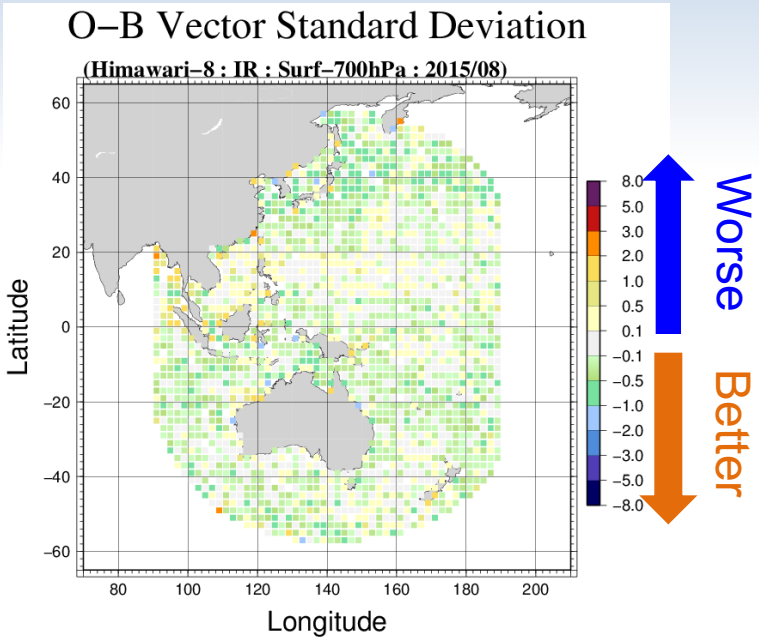
Experimental Design for Global NWP system

Name	Specification (Main differences)
CNTL	A scheme of the 200 km thinning of OPE-AMVs in the 6 hour time window
TEST	CNTL + QC for Himawari-8 AMVs (100kmSPOB etc.) (100kmSPOB for Japan and the surrounding areas and 200km thinning for the other regions) + NO MTSAT-2 AMVs

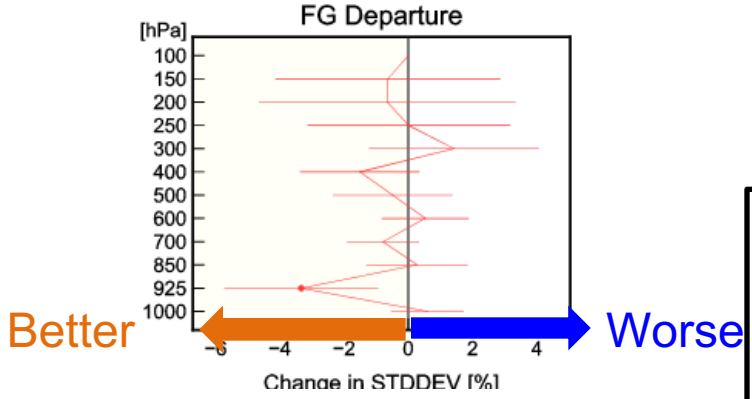
- Period
  - Winter 2015
    - Assimilation : From 17 January to 11 March 2015
    - Forecast : From 17 January to 28 February 2015
  - Summer 2015
    - Assimilation : From 3 July to 11 September 2015
    - Forecast : From 3 July to 11 September 2015

Data coverage and wind speed STD differences between TEST and CNTL on analyzed fields





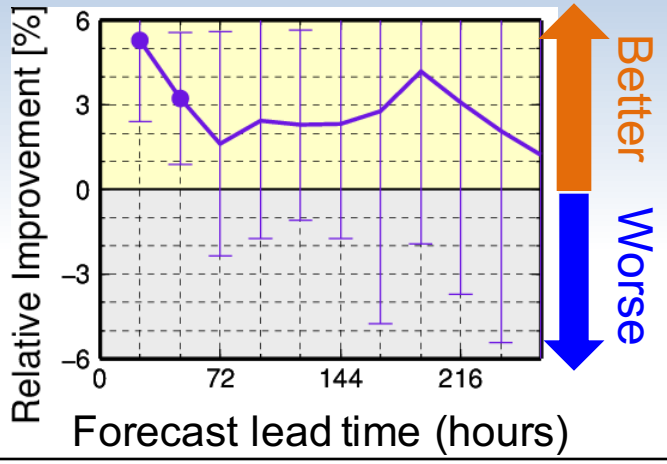
O-B wind speed STD differences below 700 hPa for summer 2015



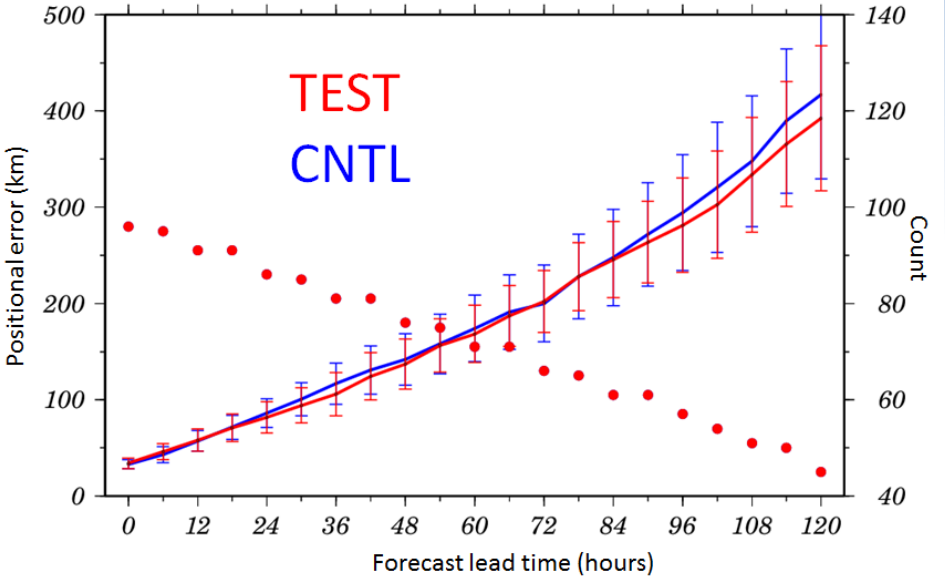
Normalized O-B wind speed STD differences against JMA's wind profiler observations for summer 2015

- Improved data coverage
- Reduction of O-B wind speed differences over the Himawari-8 observation area (especially around Japan)
- Impact of revision of derived wind vector methods and introduced SPOB around Japan

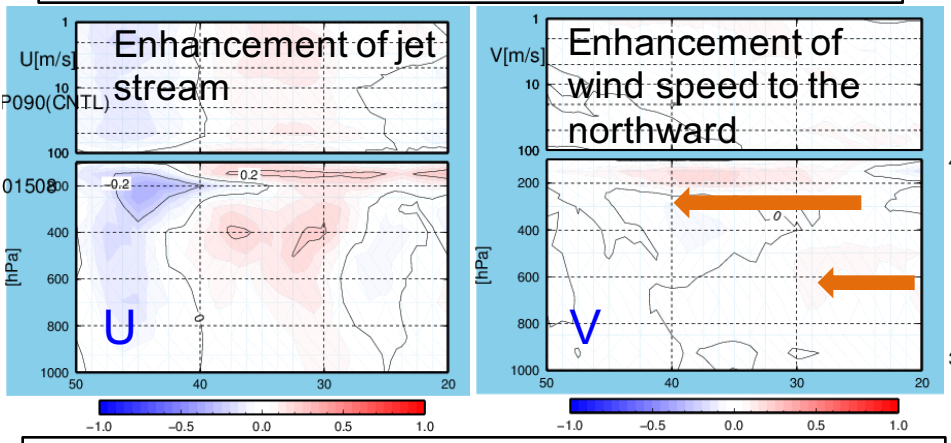
Results of OSE in summer 2015



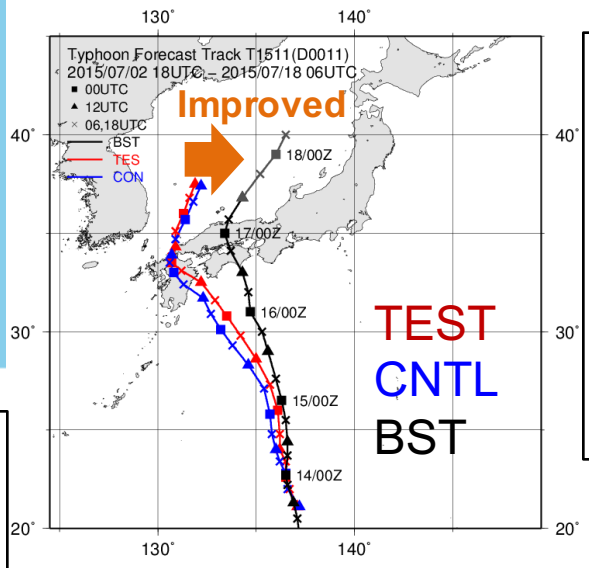
Normalized RMSE differences around Japan between TEST and CNTL for 850 hPa wind vectors



Average of typhoon positional errors



Analyzed field of U-component and V-component winds around Japan
(Zonal mean meridional cross sections: TEST-CNTL)



Typhoon track forecast of NANGKA (T1511) initialized at 12 UTC on 13 July 2015.

Summary (1/2)

- Characteristics of Himawari-8 AMV
  - Use of new tracking and new height assignment algorithms
  - Proper Gaussian distributions in data assimilation
  - Better accuracy Himawari-8 AMVs comparing to MTSAT-2 AMVs
- QC for Himawari-8 AMV
  - Revised QI with forecast thresholds for low-quality AMV rejection
  - Revised climatological checking
  - Introduction of a 100-km super-observation technique (SPOB) for Japan and the surrounding areas
- Results of OSEs
  - Modification of atmospheric general circulation (especially Himawari-8 observation area)
    - Enhancement of wind speed to the northward
    - Enhancement of jet stream, and shift of the stream to the southward

Summary (2/2)

- Result of OSE (continuation)
  - Reduction of O-B wind speed differences over the Himawari-8 observation area (especially around Japan)
  - Significant improvements (up to 3 – 6% on average) for 850 hPa wind vectors until two-day forecasts around Japan for summer 2015
  - Improvement of mean typhoon positional errors
    (The reduction was around 6 % with 24-hour to 48-hour forecast lead times.)
  - Positive impacts on most physical elements and heights in the Southern Hemisphere were also seen in four-day forecasts for winter 2015 (not shown)
  - Positive or neutral impacts for other physical elements and heights/regions
- Himawari-8 AMVs with the revised pre-processing system have introduced in the JMA's operational NWP systems since 17 March 2016.

Future plans

- Introduction of minor revision of QC for Himawari-8 AMV in October 2016
  - Rejection of Himawari-8 AMVs with negative wind speed biases associated in jet stream
- Proper region expansion from Japan areas of AMVs with SPOB method into the global NWP system
- Use of Himawari-8 AMVs with SPOB method into the regional NWP systems
  - Consideration of super-observation procedure in the appropriate area and grid size
- Use of new polar AMVs in 2017
  - S-NPP/VIIRS, Dual-Metop/AVHRR, Terra/MISR, Aqua/AIRS

THANK YOU FOR YOUR ATTENTION


BACK UP

NWP system for OSE

Today's talk	Global (GSM-DA)	Meso-Scale (MSM-DA)	Local (LFM-DA)
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	100/0.01 hPa	48/21.8 km	58/20.2 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

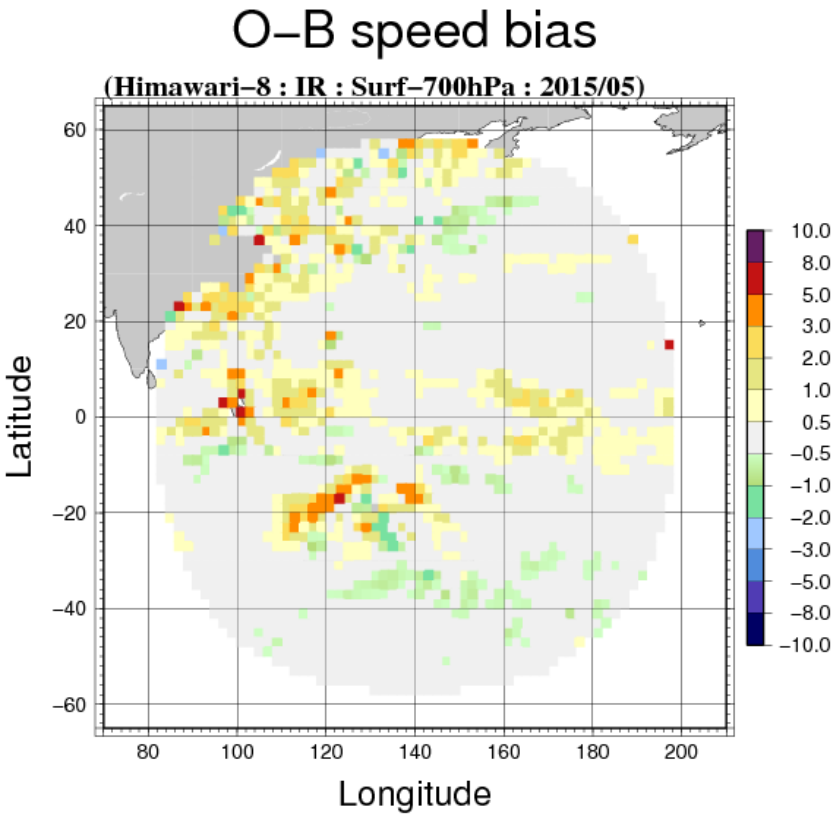
QI thresholds

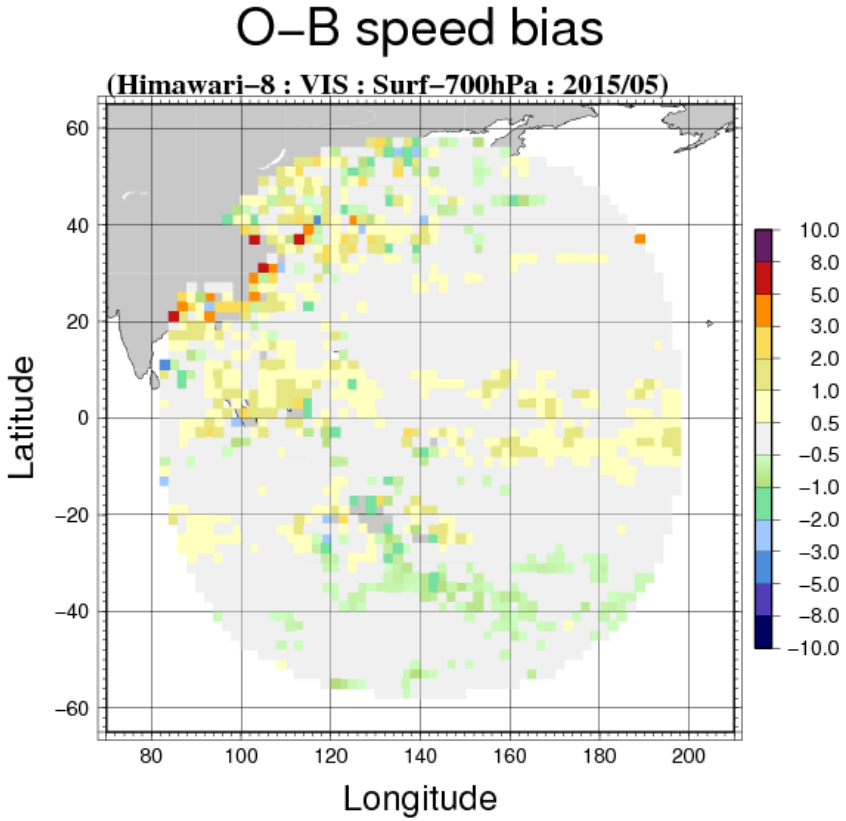
- Revised in consideration of Himawari-8 AMV characteristics

Area	Sensor	HL (≦400hPa)	ML (400-700hPa)	LL (≧700hPa)
NH (polewards of 20N)	IR (B07+B13)	85	94	88
	VIS (B03)	88	95	85
	WV (B08+B09+B10)	85	85	—
EQ (20S-20N)	IR	85	85	88
	VIS	95	90	85
	WV	85	85	—
SH (polewards of 20S)	IR	92	91	93
	VIS	96	96	85
	WV	95	85	—

Climatological checking

- Rejection of IR and VIS AMVs over land below 700 hPa
- Use of AMVs in the middle troposphere





OSE FOR HIMAWARI-8 AMV USING MESO-SCALE NWP SYSTEM (MSM)

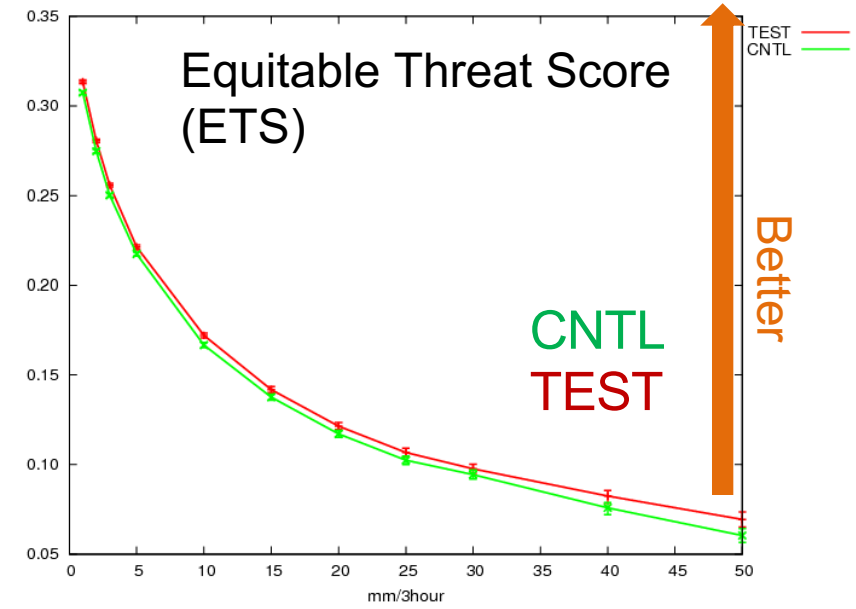
Experimental Design for Meso-scale NWP system

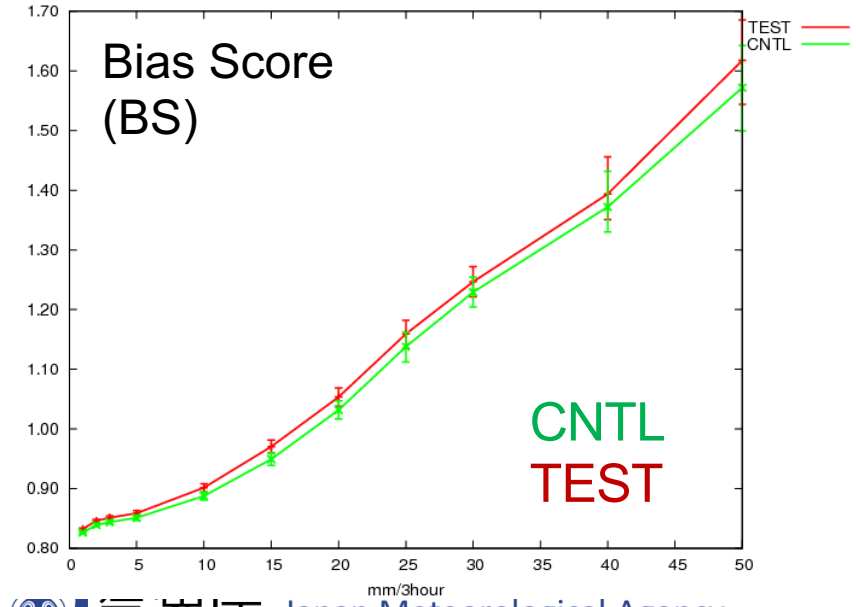
Name	Specification (Main differences)
CNTL	A scheme of the 200 km thinning of OPE-AMVs in the 3 hour time window
TEST	CNTL + QC for Himawari-8 AMVs (same as a scheme of CNTL) + NO MTSAT-2 AMVs

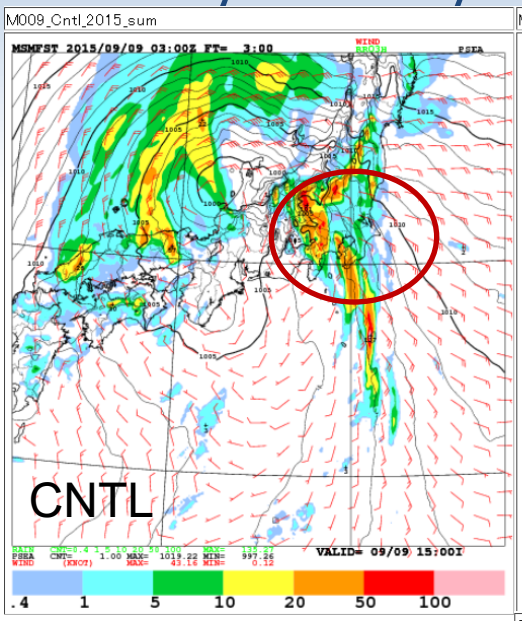
- Period
  - Summer 2015
    - Assimilation : From 7 August to 11 September 2015
    - Forecast : From 7 August to 11 September 2015

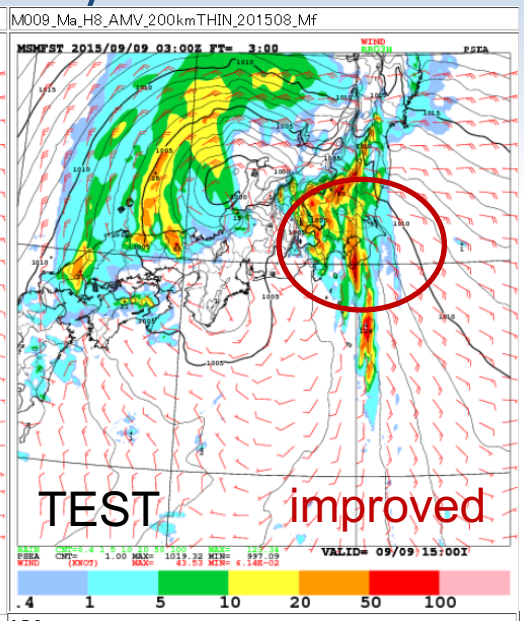
Result of OSE

(Rain Score and Case Study of heavy rain)

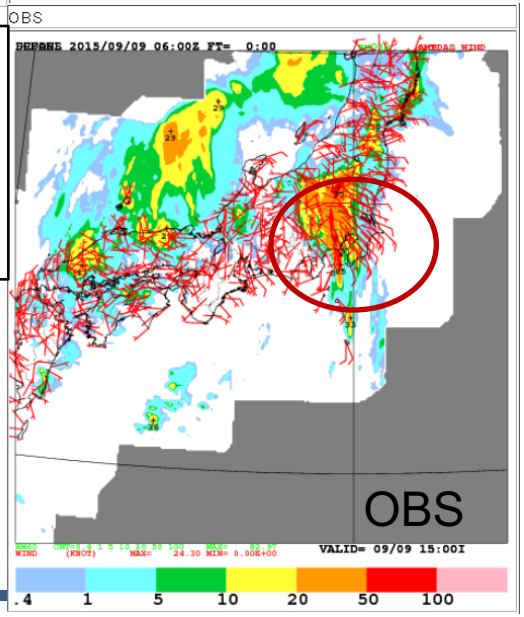




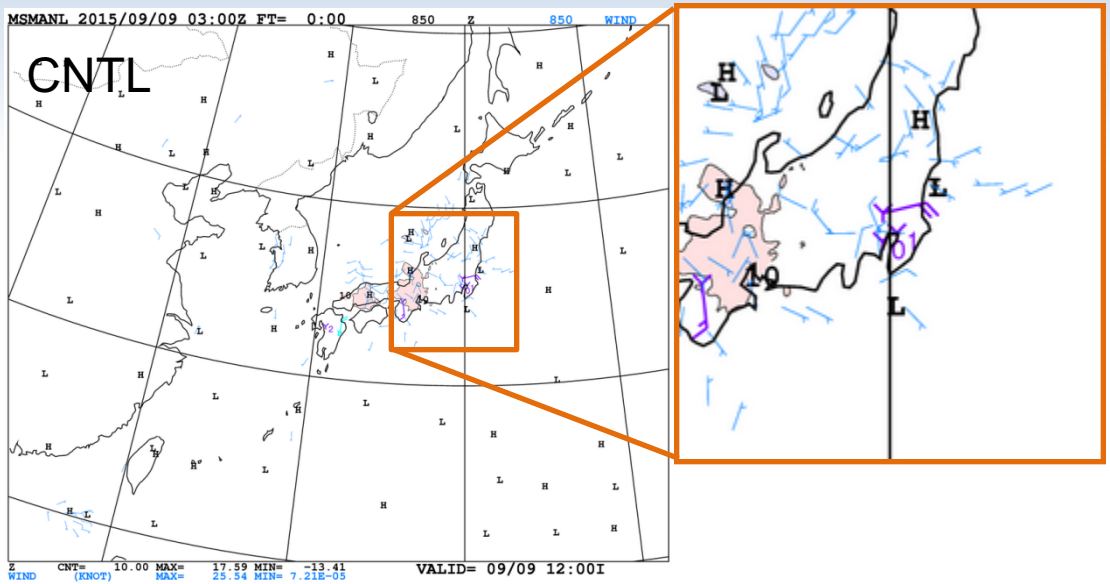


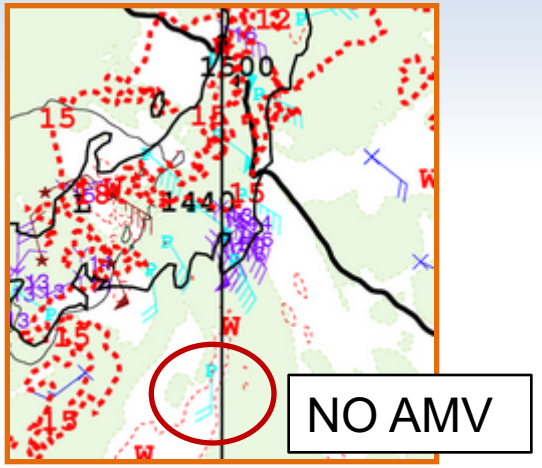


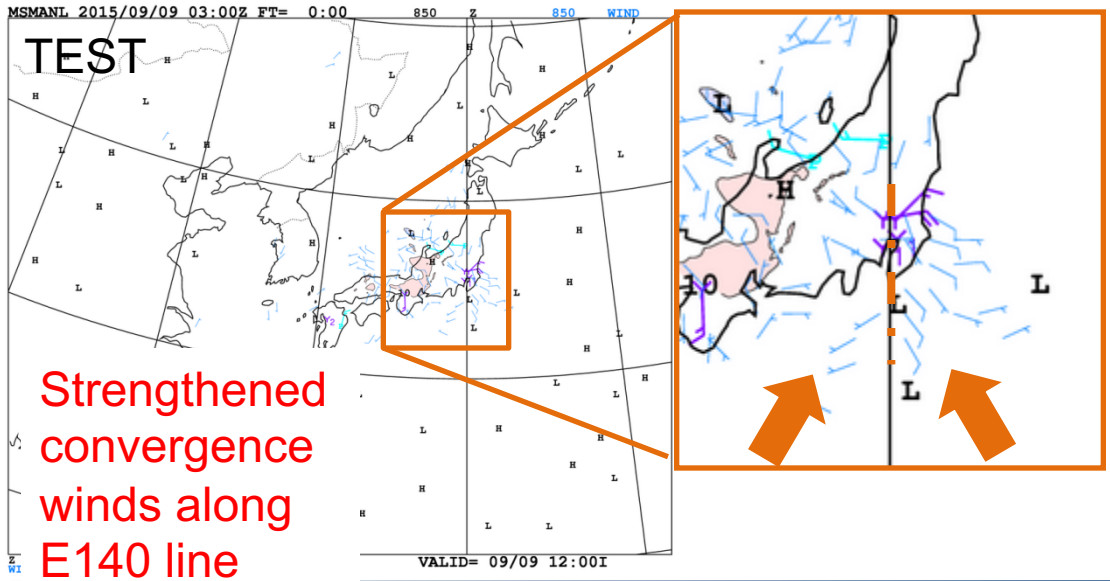
A case study of Kanto-Tohoku heavy rain
（FT=03 at 03 UTC
9 September, 2015）



Increment of geopotential height and winds for 850 hPa at 03 UTC 9 September 2015







Strengthened convergence winds along E140 line