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

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Outline

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

Due to time constraints, today's talk is "Assimilation of Himawari-8 AMVs into the operational global NWP System of JMA".
Hereafter the items associated with regional NWP Systems are abbreviated.

Background

- The Meteorological Satellite Center (MSC) of JMA started production of Himawari-8 AMVs as replacement of MTSAT-2 AMVs on 7 July 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.
- JMA/MSC also started producing Himawari-8 Rapid Scan Atmospheric Motion Vectors (RS-AMVs), as trial. (The impacts for RS-AMVs are going to be presented in today's poster session.)

Purpose

- To start assimilating Himawari-8 AMVs in JMA's operational NWP Systems with maximizing its impact
- For this purpose,
  - To review the quality of Himawari-8 AMVs by comparing with MTSAT-2 AMVs in detail
    - Characteristics of Himawari-8 AMV
  - 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 including typhoons
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

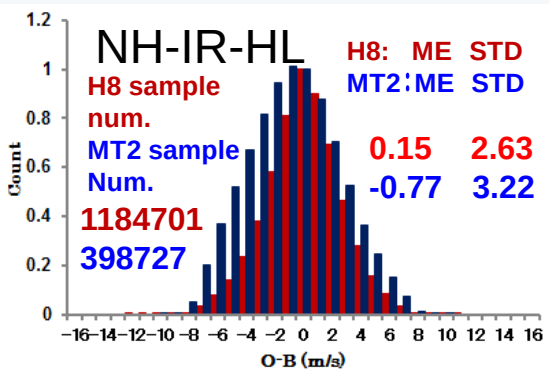
Characteristics of Himawari-8 AMV

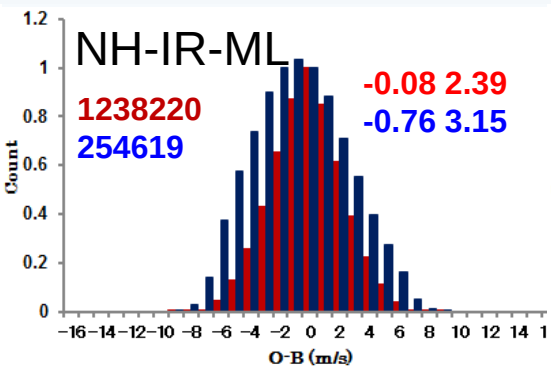
- Evaluated statistically against the first guesses of the GSM-DA
- Compared with MTSAT-2 AMVs
- Conditions
  - Over 60 Quality Indicator (QI) with forecast
  - Period: From 5 February to 20 March 2015
  - Investigation items
    - Histograms of the normalized difference (O-B) between the relevant wind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

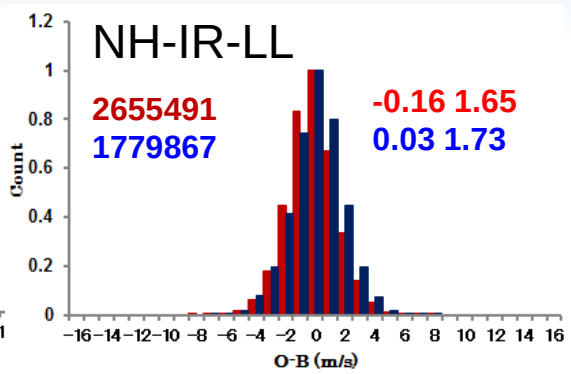
O-B normalized histograms of Himawari-8 AMVs in the Northern Hemisphere (poleward of 20N)

HL ML LL

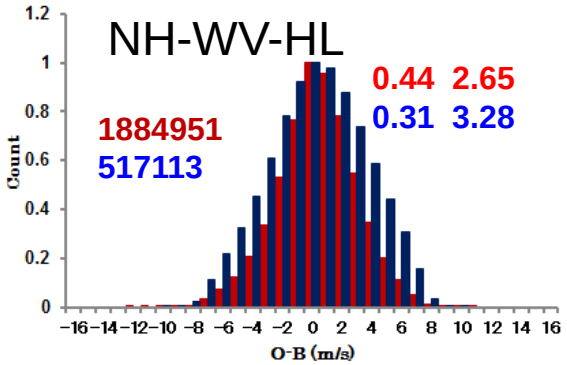
IR (B07 +B13)







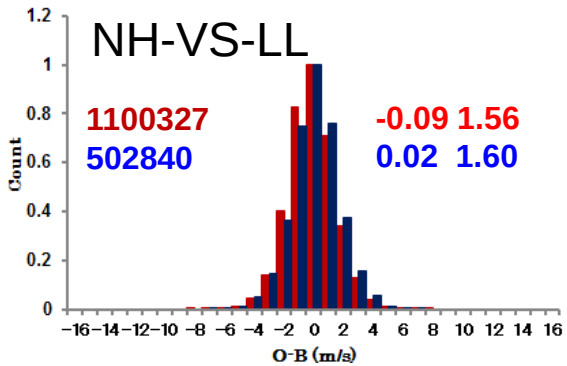
WV (B08 +B09 +B10)



Himawari-8

MTSAT-2

VIS (B03)



ME: Mean Error (unit m/s)
STD: Standard Deviation (unit m/s)
O-B: first guess departure

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 by investigation of relation between QI and O-B wind speed
  - Revised climatological checking by investigation of O-B wind speed
    - 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 (SPOB) for Japan and the surrounding areas into the global NWP system (introduced a 200-km thinning scheme for the other regions)
    - Introduced rejection of Himawari-8 AMVs with wind speed biases associated in jet stream from 15 December 2016.
- 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)

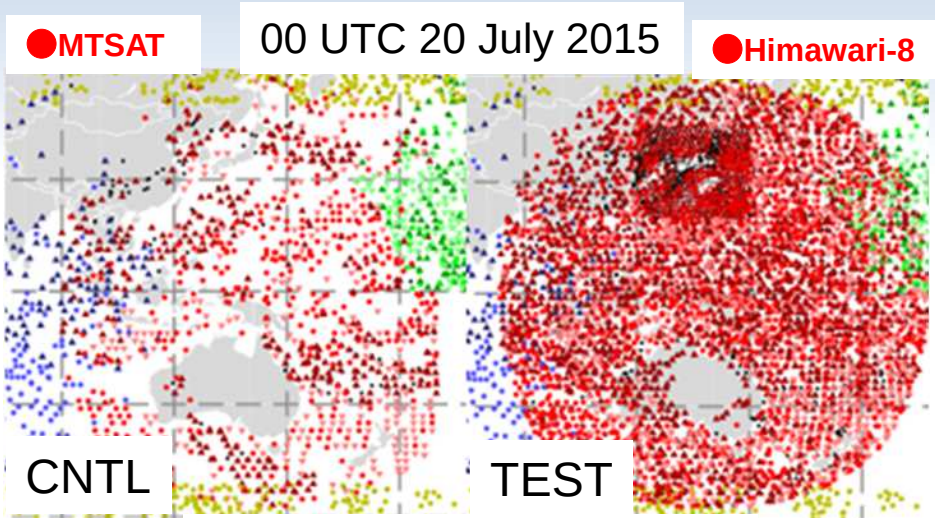
OSE FOR HIMAWARI-8 AMV

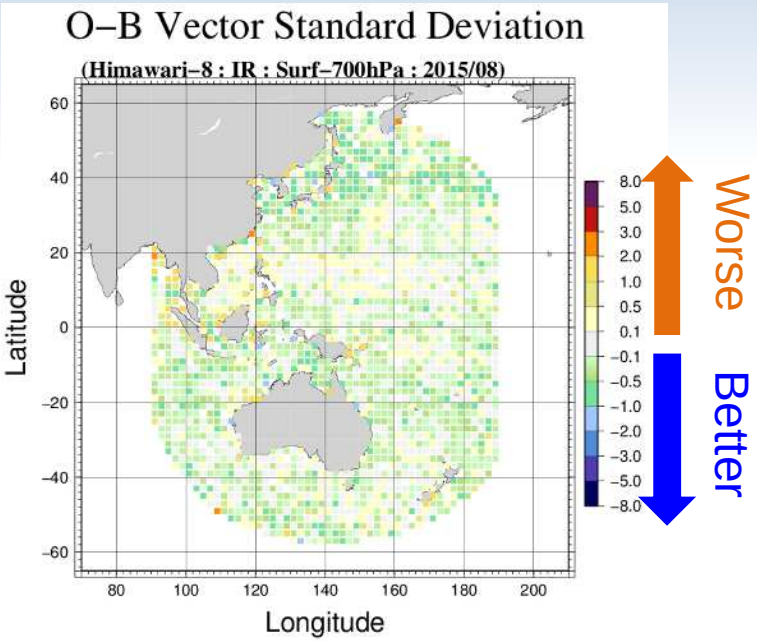
Experimental Design for Global NWP system

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

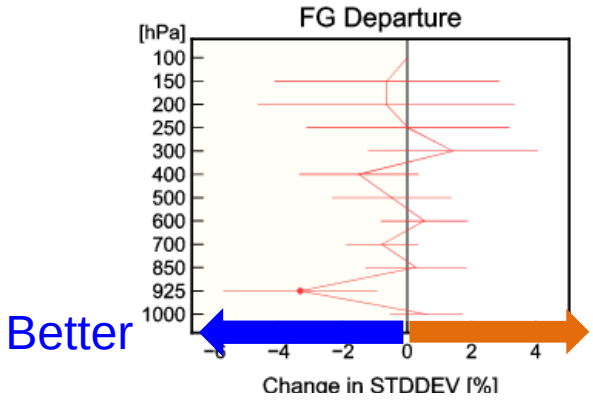
- Period
  - Winter 2015
    - Assimilation : From 17 January to 11 March 2015
    - Forecast : From 17 January to 28 February 2015
  - Summer 2015
    - Assimilation : From 3 July to 11 September 2015
    - Forecast : From 3 July to 11 September 2015

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





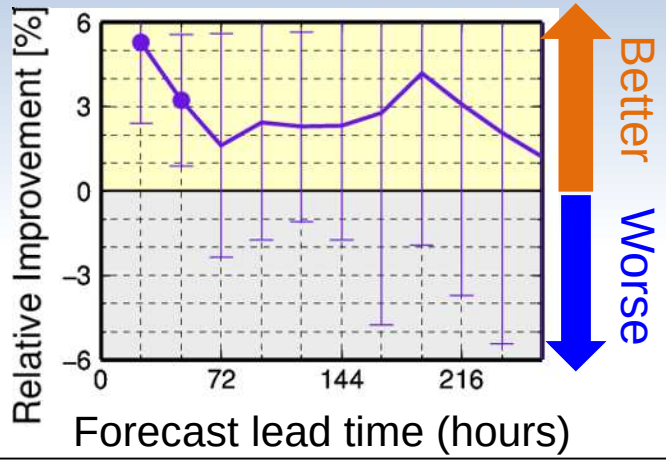
O-B wind speed STD differences (TEST-CNTL) below 700 hPa for summer 2015



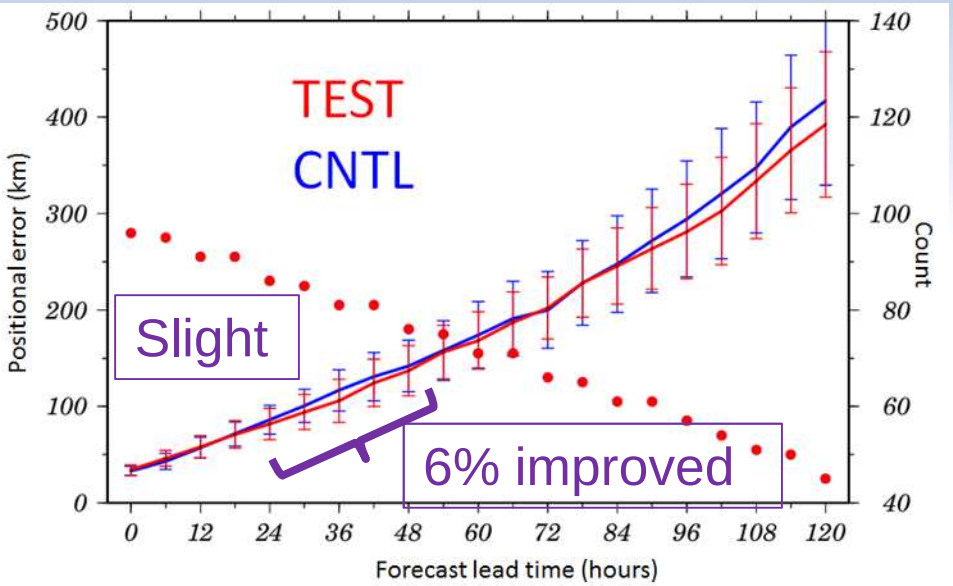
Normalized O-B wind speed STD differences against JMA's wind profiler observations for summer 2015

- 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

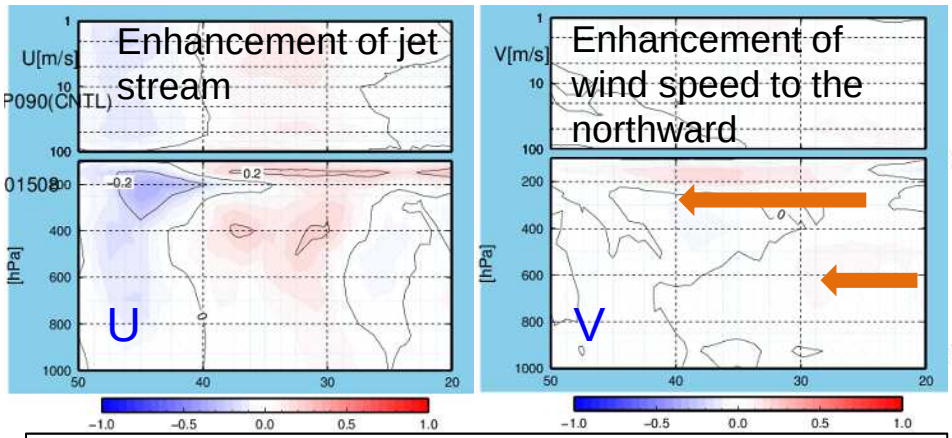
Results of OSE in summer 2015



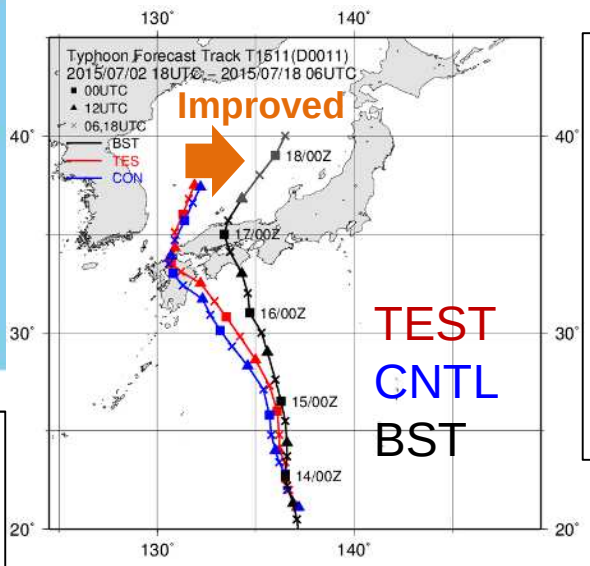
Normalized RMSE differences around Japan between TEST and CNTL for 850 hPa wind vectors



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
  - Slight 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

- 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