Development of AMV height assignment directly linked to feature tracking at JMA

Ryo OYAMA [1], Régis Borde [2], Johannes Schmetz [2] and Toshiyuki KURINO [1]

1 Meteorological Satellite Center (MSC) of Japan Meteorological Agency (JMA)

2 EUMETSAT, Am Kavalleriesand 31, D-64295 Darmstadt, Germany

9th International Winds Workshop in Annapolis

14-18 April 2008

Contents

◆Motivation

◆Introduction of individual-pixel contribution to feature tracking

◆Methodology

◆Results of application study

◆Concluding remarks and future plans

Motivation (1/2)

Height assignment by using coldest pixel radiances (i.e. upper most clouds) within template image for feature-tracking is the most common.

- **EUMETSAT**

Coldest peak of cloud top height histogram of Cloud Analysis (CLA) product (ASD internal EUMETSAT document).

- **NOAA/NESDIS**

Fixed threshold of 25 % coldest pixels for GOES instruments (Daniels, 2002)

- **JMA**

The most frequent cloud height derived from height-histogram accumulated in 50-hPa intervals (Oyama and Shimoji, 2008). In many cases, the height of uppermost cloud is selected because uppermost clouds are selected for the targets in the target selection.

Motivation (2/2)

However…

Is using a height computed by using an amount of coldest pixels within the template image always adequate ???

In fact, AMV producers have to deal with various template images containing clouds with different height and speed.

Some information which can link AMV height to feature-tracking is desired …

- Buche et al. (2006) considered individual pixel contribution (CCij) to feature-tracking in using cross-correlation matching, and they applied the information to the height assignment for clear-sky-region WV AMVs.

In this study, the individual pixel contribution to feature-tracking is applied to height assignment for **IR AMVs** using MTSAT-1R images and JMA's AMV processing system.

Introduction of individual-pixel contribution to feature-tracking (1/2)

Definition of individual contribution rate to feature-tracking (CCij) under cross-correlation matching:

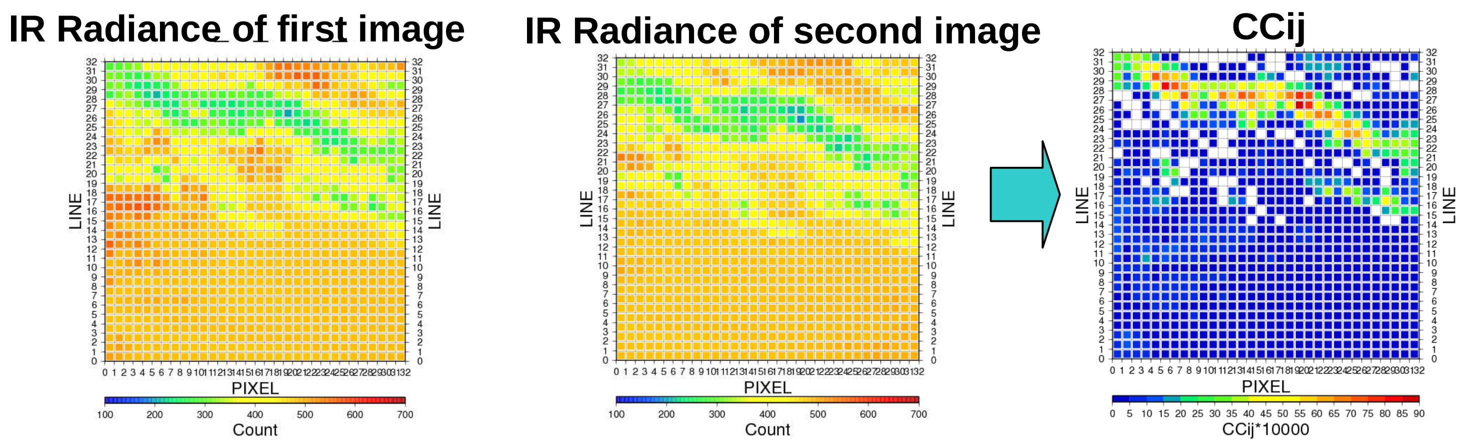
$$cc(m,n) = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{A_{i+m,j+n}-A_{mean}(m,n)}{\sigma_A(m,n)}\frac{B_{ij}-B_{mean}}{\sigma_B} = \sum_{i,j}^{M,N} cc_{ij} \qquad \text{(Eq.1)}$$

CC (m,n): cross-correlation at the location best corresponding to the target in the second searching image

M, *N*: template image size (=32 at JMA, 24 at EUMETSAT)

A_{ij}, B_{ij}: each-pixel (i, j) IR radiance of target image and searched area image on the second searching image

A_{mean}, B_{mean}: averages of A and B, CCij : each pixel (i, j) contribution rate to feature tracking of each pixel (i, j)



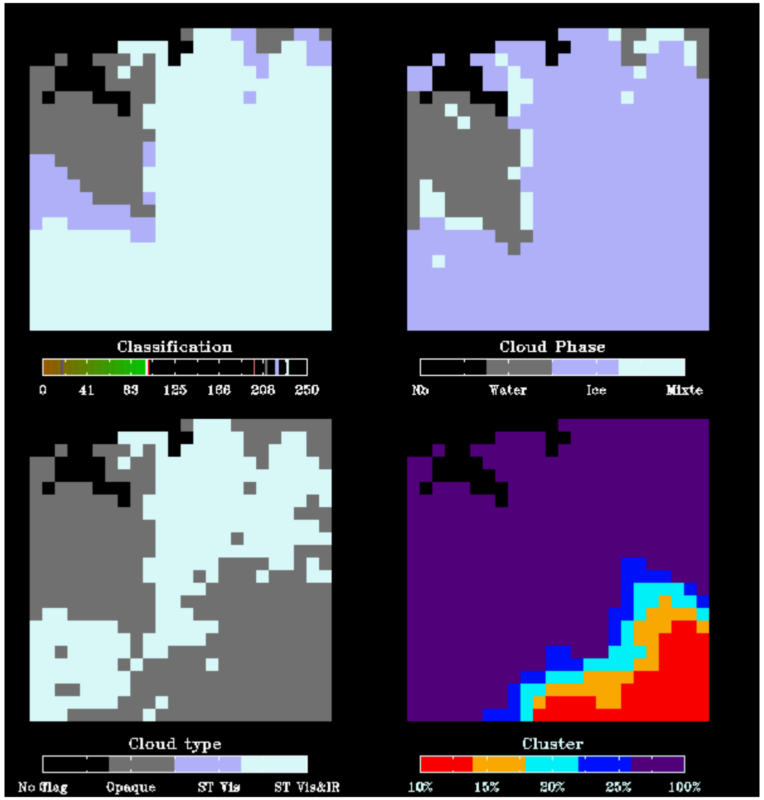
Introduction of individual-pixel contribution to feature-tracking (2/2)

Borde and Oyama (2008) investigated some possibility to select available pixels for AMV height assighment.

Some Problems remain in the application of CCij to height assignment:

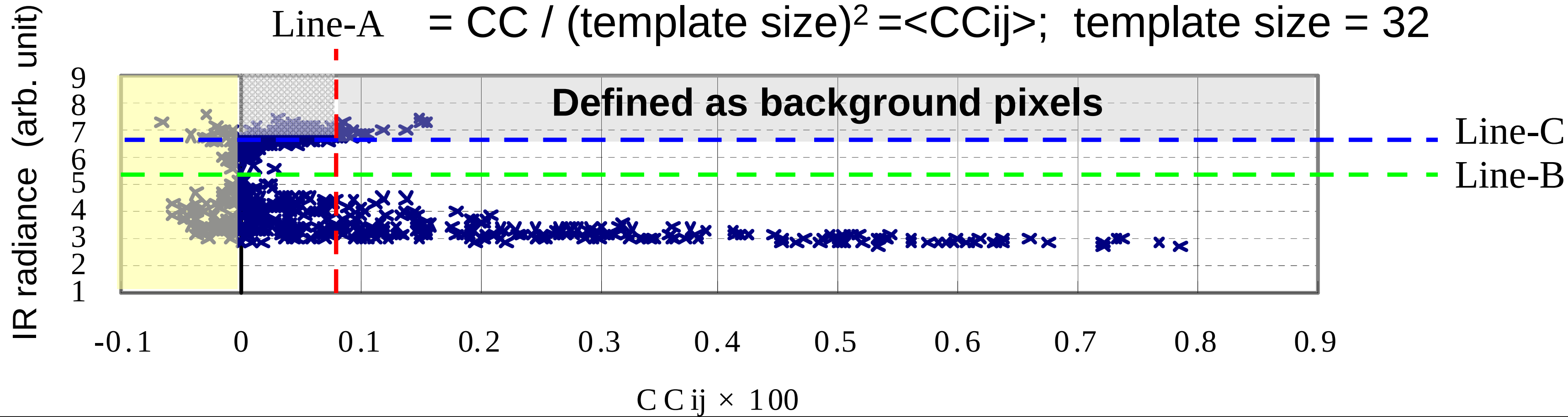
(1) How can we introduce CCij into height assignment ?

(2) How many pixels should be used for height assignment ?   10% , 15%, 20%, 25%, 100% coldest pixels ???



Example of cloud clustering for a template image (Borde ,2006)

Methodology (1/3)



Green Line (Line-B): Average of IR pixel-radiances in template image
Blue line (Line-C): Intersection of Line-A and quadratic curve of pixel distribution

Radiance for IR AMV heights (L1) :

$$L1 \equiv \frac{1}{\sum_{i,j}^{pixels\_in\_Area1} CC_{ij}} \sum_{i,j}^{pixels\_in\_Area1} L_{i,j}^{cor} \times CC_{ij} \qquad \text{(Eq.2)}$$

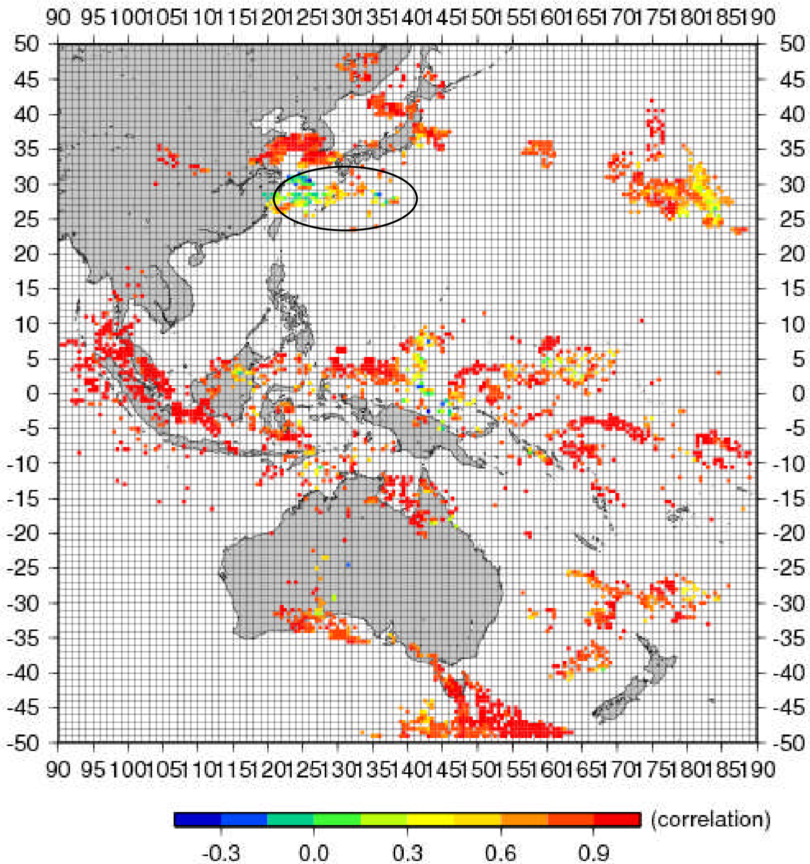
L_{ij}^{cor} : IR radiance corrected by H2O-IRW intercept method

- Pixels over grey region or yellow region are not used for computing L1.
- L1 is finally converted to an IR AMV height via MTSAT-1R's conversion table between IR radiance and temperature, and vertical profile data of JMA's NWP (Global Spectral Model (GSM)) first-guess.

Methodology (2/3)

In preliminary research to apply L1, it was noticed some modifications on the procedure were necessary in using JMA's processing system.

(1) Need to distinguish cloud types properly



Cross-correlation between IR and WV EBBT

For lower height-level cloud targets, the AMV heights computed by using L1 is generally higher than the best-fit levels to sonde observation or NWP.

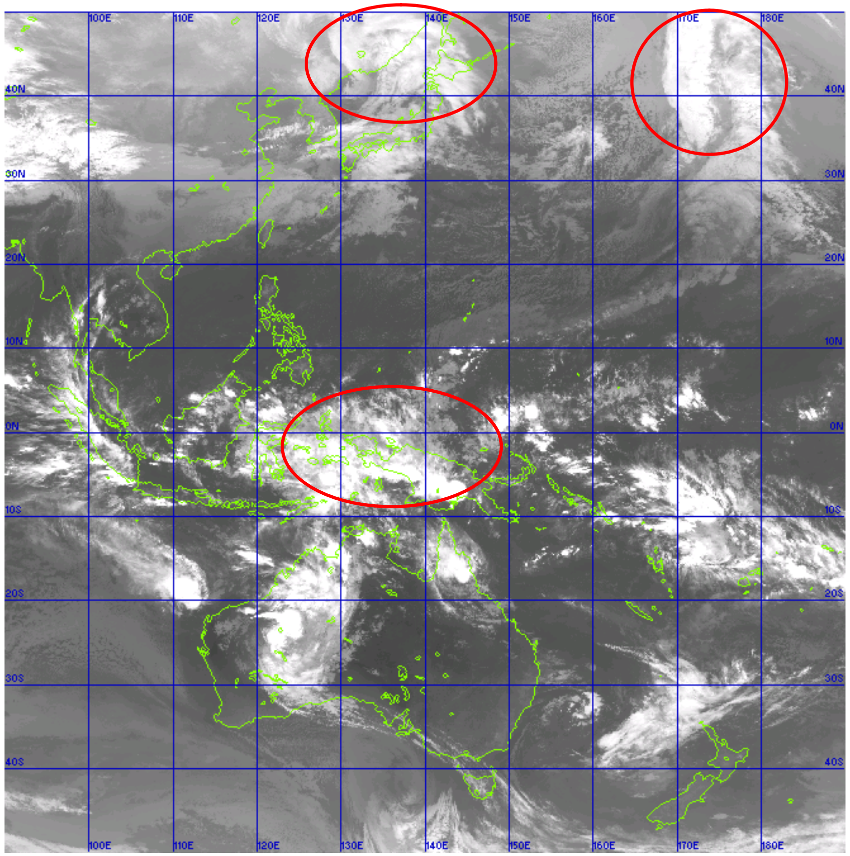
Need to distinguish low-height-level cloud targets

Introduce correlation between template images of IR and WV EBBT (Xu et al. , 1998).

- If cloud targets below 400 hPa height-level from L1 have the correlation less than 0.35, they are assigned to 'stable layer-base' which is computed by using IR EBBT of cloud pixels around the cloud top.

Methodology (3/3)

(2) Need to eliminate the influence of convective cloud pixels in cyclone regions



Some convective-cloud pixels with large time variability and positive CCij are found in cyclone region.

In this study, the minimal coldest pixels is not used to compute L1. The threshold (1.5 %) is determined not to have significant influence on AMV heights.

➢We consider the application of this procedure is arbitrary and dependent on IR AMV target selection and height assignment processes.

Results of application study (1/5)

Comparison between Test AMVs and three AMVs assigned to heights computed by using 10, 15 and 25 % coldest pixel average radiances

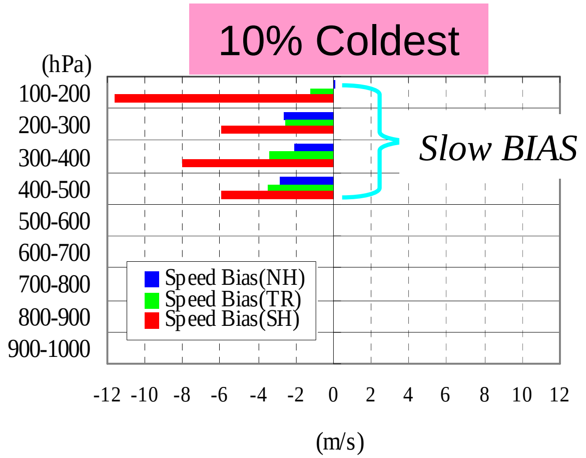
BIAS of IR AMVs (QI>0.85) against JMA's NWP (60 km GSM) first-guess at each-height level

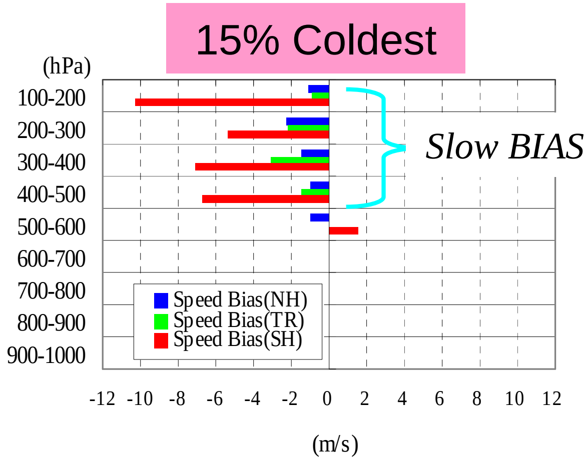
Statistics for *00UTC 05 September 2007*

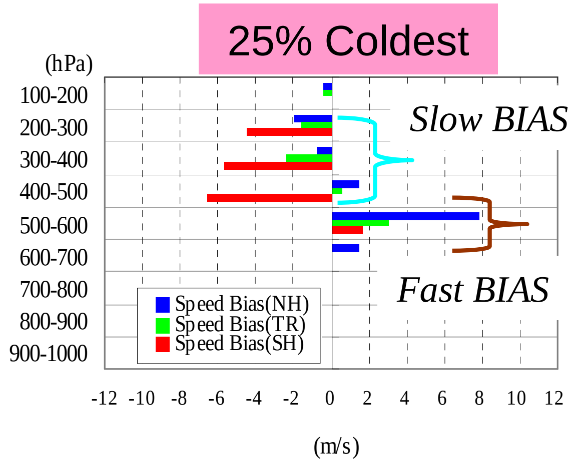
Blue: Northern hemisphere (50-20N)

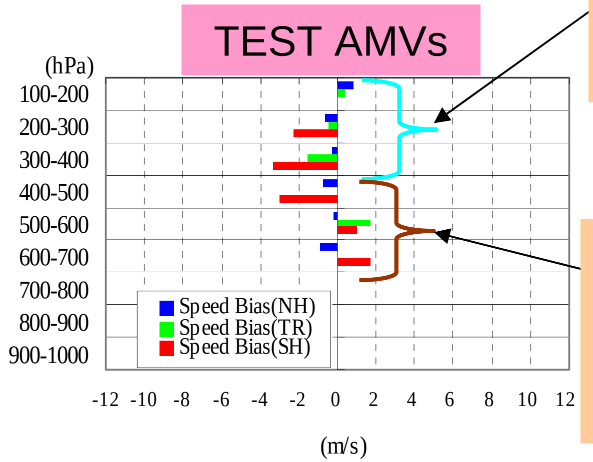
Green: Tropics (20S-20N)

Red: Southern hemisphere (50-20S)









Slow BIAS of TEST AMVs at levels above 500 hPa is smaller than that of 10, 15 and 25 % coldest pixel height AMVs.

Fast BIAS between 500 and 600 hPa for 25% coldest height-level AMVs is not recognized for TEST AMVs.

Results of application study (2/5)

Comparison between current JMA's AMVs (RTN) and TEST AMVs

Monthly statistics of IR AMVs (QI>0.85) against JMA's NWP (60km GSM) first-guess at each height-level

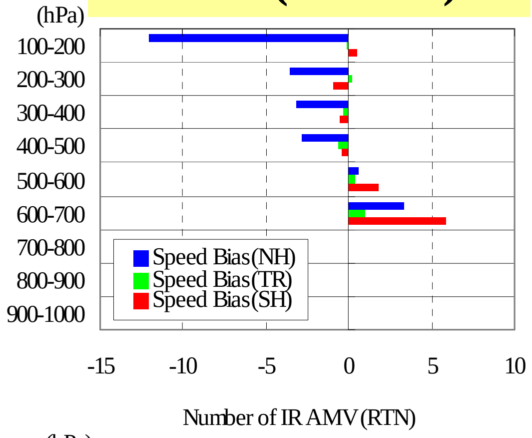
Statistics for *March 2007*

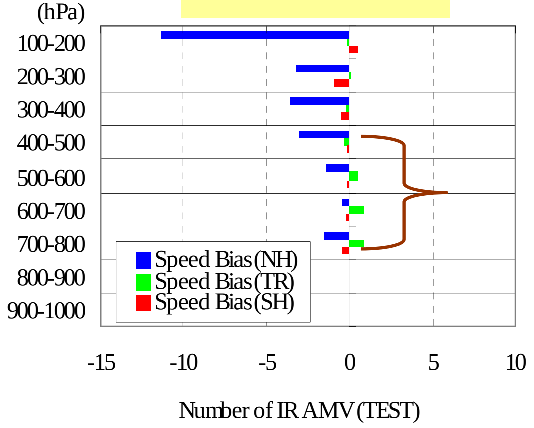
RTN (current)

TEST

What impacts ?

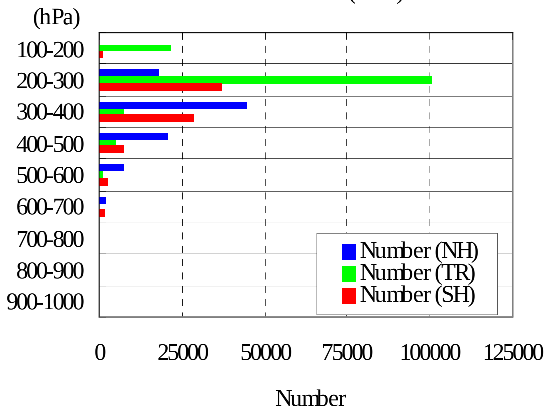
BIAS

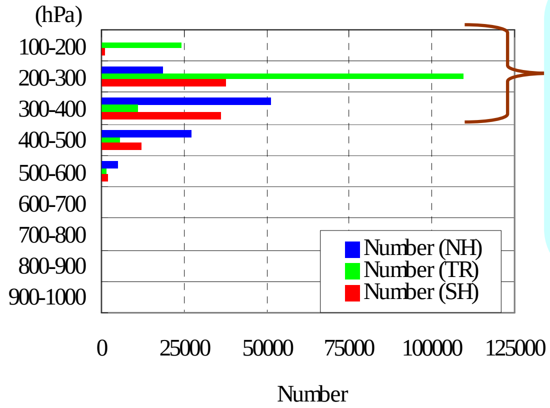




Fast BIAS of RTN AMVs at levels of 500-700 hPa are resolved in TEST AMVs.

Number





Number of TEST AMVs is larger than that of RTN AMVs, particularly at upper height-level.

larger data-coverage than RTN AMVs !

Results of application study (3/5)

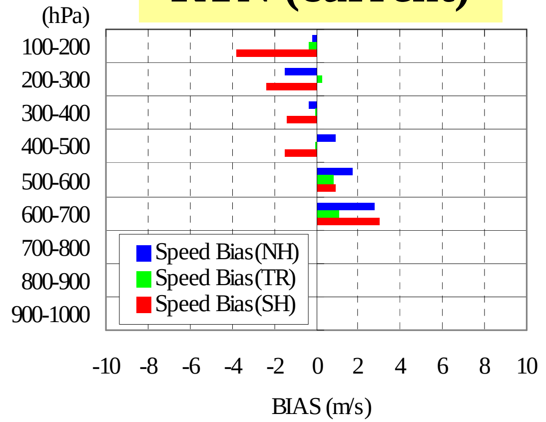
Comparison between current JMA's AMVs (RTN) and TEST AMVs

Monthly statistics of IR AMVs (QI>0.85) against JMA's NWP (60km GSM) first-guess at each height-level

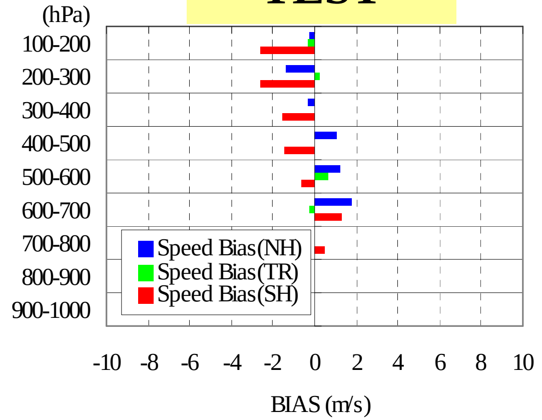
Statistics for *September 2007*

BIAS

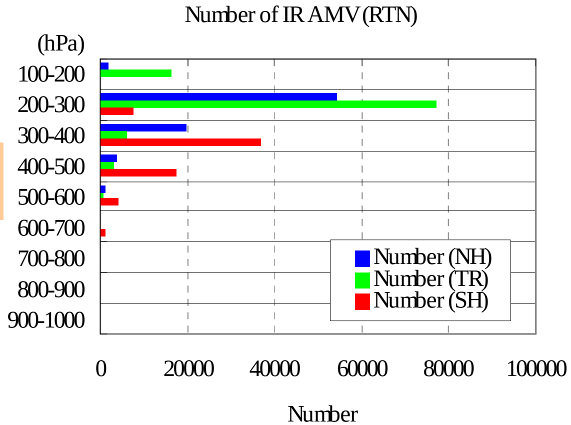
RTN (current)

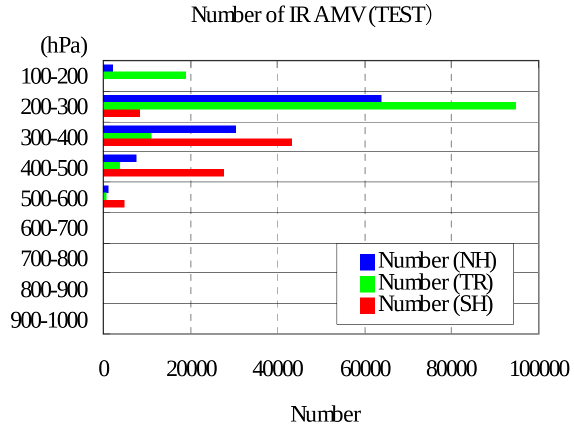


TEST



Number





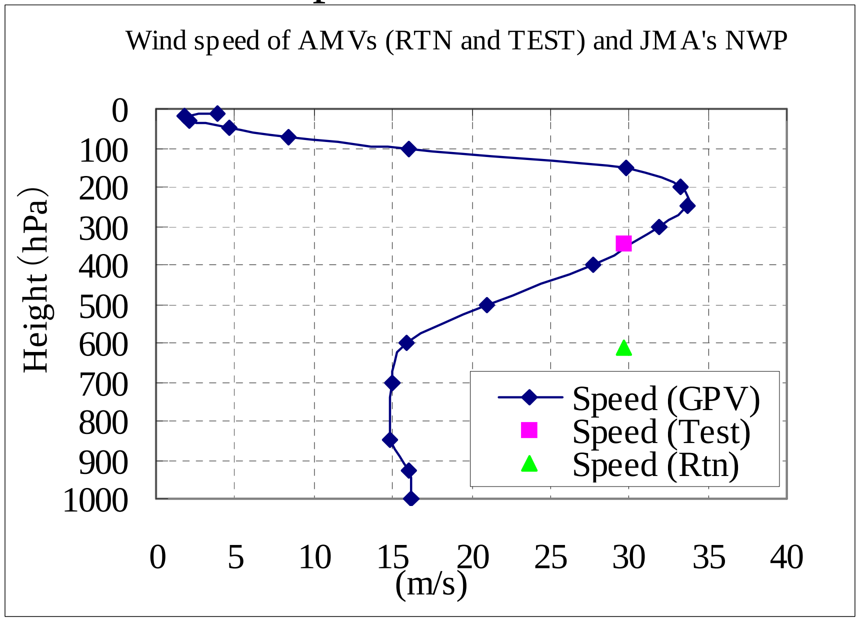
What impacts ?

Same positive impacts as March 2007 are found for September 2007.

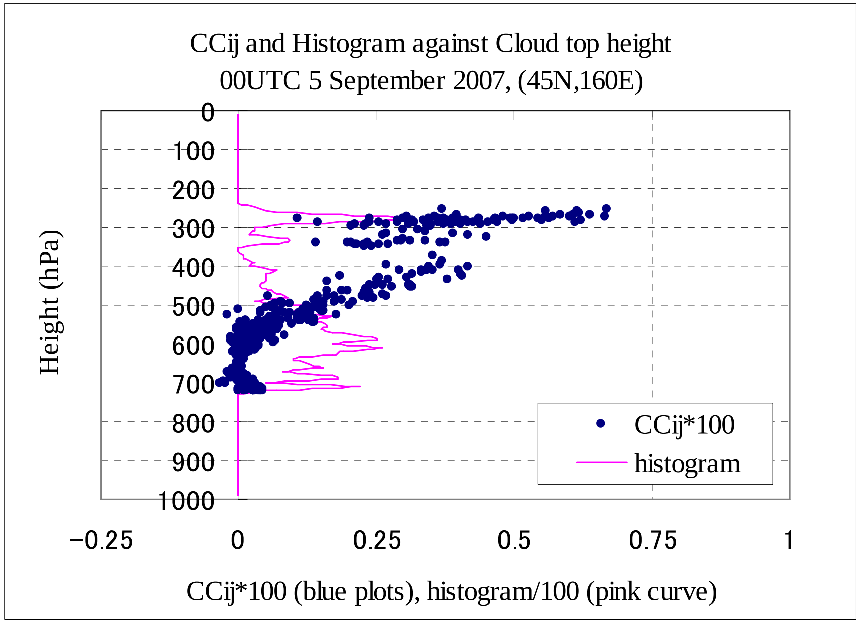
Results of application study (4/5)

How the positive impacts by the use of TEST scheme are obtained ?

A comparison between TEST AMVs and RTN AMVs at a location



Wind speeds of AMVs (**RTN (Green**) and **TEST (Pink)**, and **JMA's NWP wind speed (Blue curve)**



Scatter plots of CCij against cloud-top height (Blue), and histogram of cloud-top-height (Pink)

In this case, RTN AMV is erroneously assigned to too low height-level (about 600 hPa) because CCij is not used for the current JMA's height assignment.

The use of CCij can resolve the error of height assignment, particularly, fast BIAS at middle-height-level observed in current JMA's IR AMVs !

Results of application study (5/5)

Comparison between current JMA's AMVs (RTN) and TEST AMVs

Monthly statistics of IR AMVs (QI>0.85) against sonde observation

Statistics for *March 2007*

Upper height level (Above 400 hPa)	NH (20N-50N)		TR (20S-20N)		SH (50S-20S)	
	RTN	TEST	RTN	TEST	RTN	TEST
MEAN SPEED (m/s)	33.4	33.4	14.5	14.5	23.4	23.1
BIAS (m/s)	-3.0	-3.1	-0.6	-0.8	-0.3	-0.6
RMSVD (m/s)	9.1	8.9	5.9	5.8	6.7	7.0
Number of collocated AMVs	6297	7084	7339	7955	2194	2373

Middle height level (700 hPa to 400 hPa)	NH (20N-50N)		TR (20S-20N)		SH (50S-20S)	
	RTN	TEST	RTN	TEST	RTN	TEST
MEAN SPEED (m/s)	25.7	25.2	11.1	11.1	16.1	17.2
BIAS (m/s)	-2.2	-3.8	-2.1	-1.4	-0.1	0.3
RMSVD (m/s)	9.0	9.3	5.3	4.7	5.4	5.7
Number of collocated AMVs	3365	3388	212	209	242	314

Statistics for *September 2007*

Upper height level (Above 400 hPa)	NH (20N-50N)		TR (20S-20N)		SH (50S-20S)	
	RTN	TEST	RTN	TEST	RTN	TEST
MEAN SPEED (m/s)	24.9	24.5	14.9	14.8	28.5	29.0
BIAS (m/s)	-1.8	-2.1	-0.4	-0.7	-1.8	-2.6
RMSVD (m/s)	7.5	7.6	6.1	6.1	8.8	9.0
Number of collocated AMVs	9621	11883	4078	4896	832	951

Middle height level (700 hPa to 400 hPa)	NH (20N-50N)		TR (20S-20N)		SH (50S-20S)	
	RTN	TEST	RTN	TEST	RTN	TEST
MEAN SPEED (m/s)	18.2	18.4	10.4	9.9	23.5	22.4
BIAS (m/s)	-0.1	0.0	0.2	0.2	-2.4	-2.6
RMSVD (m/s)	5.7	5.9	4.3	4.3	8.0	8.4
Number of collocated AMVs	1018	1336	168	219	426	691

What quality-differences between RTN AMVs and TEST AMVs are found for each tropospheric layer ?

- Slow BIASes of TEST AMVs are slightly larger than those of RTN AMVs at upper and middle height-level.

  → Probably because CCij of colder pixels are generally larger.

- RMSVDs are nearly same between RTN AMVs and TEST AMVs.

- Number of TEST AMVs is generally larger than that of RTN AMVs.

Concluding remarks and future plans (1/2)

Concluding remarks

- The weighted IR radiance (L1) of pixels within template image, balanced by CCij, is introduced to upper and middle height-level cloudy targets. It is found that TEST scheme could give well-matched AMVs to JMA's NWP first-guess field, compared to 10, 15 and 25 % coldest pixel height AMVs.
- Two noticeable improvements of TEST AMVs against RTN (current) AMVs are recognized, that is, the reduction of fast BIASes below 500 hPa and the increase of high quality (QI>0.85) AMVs particularly at upper troposphere. However, the slow BIASes of TEST AMVs are slightly larger than those of RTN AMVs.

Concluding remarks and future plans (2/2)

Future plans

- In the near future, after evaluations of more long-term monthly statistics of TEST AMVs against sonde observation and JMA's NWP first-guess, JMA plans to introduce the TEST AMVs in operation.

- CCij is useful information to select contributive cloud pixels to computing AMV heights. The information can be introduced into height assignment in various ways, using the weighted IR radiance of pixels or in conjunction with other products, for example, Cloud Analysis product (Borde and Oyama, 2008).

The End

Thank you for your attentions !

Danke schon !

GOSEICHO ARIGATOU-GOZAIMASHITA !

References (1/2)

ASD; 'MSG Meteorological Products Extraction Facility Algorithm Specification Document' edited by EUMETSAT. Reference: EUM.MSG.SPE.022.

Borde, R. ,2006: AMV height assignment methods with Meteosat-8, Proceedings of 8th International Winds Workshop.

Borde, R. and R. Oyama, 2008: A direct link between feature tracking and height assignment of operational AMVs, Proceedings of 9th International Winds Workshop.

Büche, G., et al., 2006: Water vapor structure displacements from cloud-free METEOSAT scenes and their interpretation for the wind field, J. Appl. Meteor., 45, 556-575.

Daniels, J., et al., 2002: Status and development of GOES wind products at NOAA/NESDIS, Proceedings of 6th International Winds Workshop, EUMETSAT, 71-80.

Le Marshall, J., N .Pescod, A. Khaw, and G. Allan 19, 1993: The real-time generation and application of cloud-drift winds in the Australian region. Aust. Meteor. Mag., 42, ((3),) 89-103.

References (2/2)

Nieman, N. J., Schmetz and W.P. Menzel, 1993: A comparison of several techniques to assign heights to cloud tracers, J. Appl. Meteorol., 32, 1559-1568.

Oyama, R. and K. Shimoji, 2008: Status of and future plans for JMA's Atmospheric motion vectors, Proceedings of 9th International Winds Workshop.

Schmetz, J., K. Holmlund, J. Hoffman, B. Strauss, B. Mason, V. Gartner, A. Koch, and L. van de Berg, 1993, Operational cloud-motion winds from Meteosat infrared images. *J. Appl. Meteor.*, **32,** 1206–1225.

Xu, J., Q. Zhang, F. Xiang, L. Jian, 1998: Cloud motion winds from FY-2 and GMS-5 meteorological satellites, Proceedings of 4th International Winds Workshop, 41-48.