Derivation and Application of Atmospheric Motion Vectors in KMA/NIMR

Dec. 9, 2011

Jeong-Hyun Park

Somyoung Kim, Mi-Lim Ou

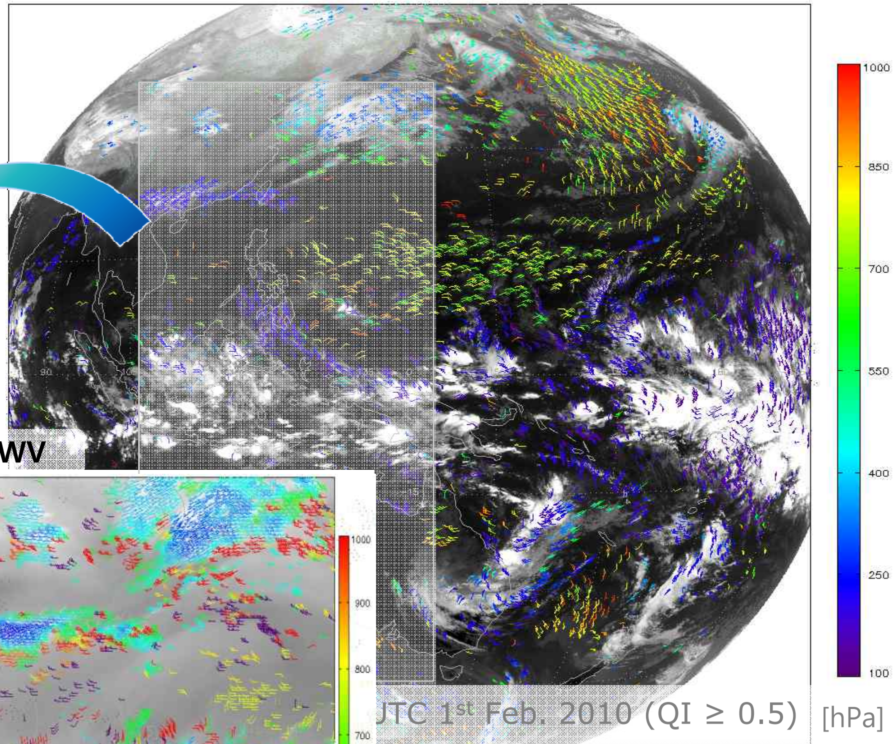
National Institute of Meteorological Research/KMA

Outline

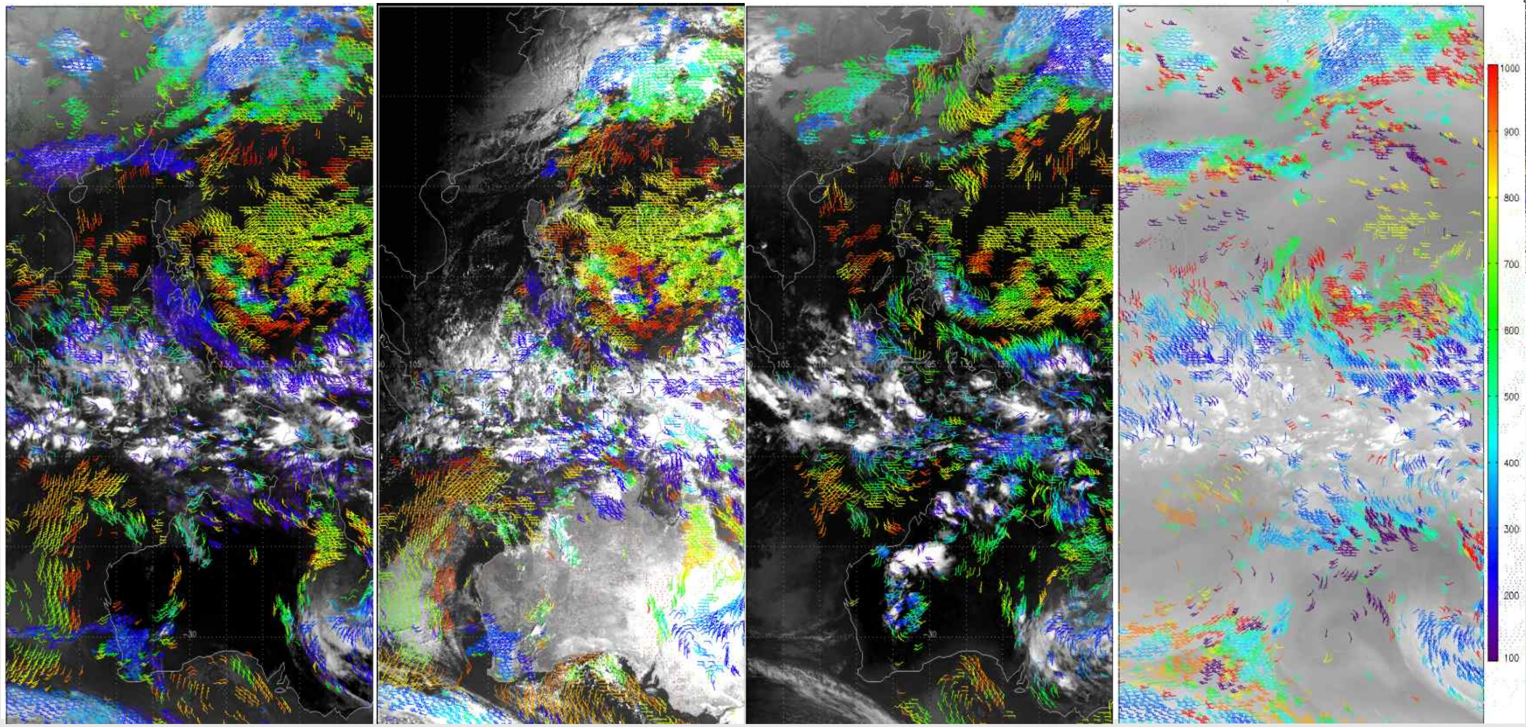
- AMV Derivation and its Characteristics
- KMA/NIMR's AMV Algorithm
- Sensitivity Tests for the AMV algorithm
- Optimization of the Mesoscale AMV algorithm
- Summary and Future Plan

AMV Derivation and its Characteristics

- Used for weather analysis and data assimilation into NWP model
- Extracted by tracking clouds and water vapor in sequential imagery
- IR, WV, VIS, SWIR channels (4km/1km res.)
- Globe (every 6 hrs), NH (every hour)



IR VIS SWIR WV



KMA/NIMR's AMV Retrieval Algorithm

Geostationary Satellite Observation
- Level 1B data for IR, WV, SWIR, VIS

Simulated BT by RTM (RTTOVS 9)

Scene Analysis with Cloud Detection

Target Selection
- Regular/Optimal Target Location (RTL/OTL)

Height Assignment

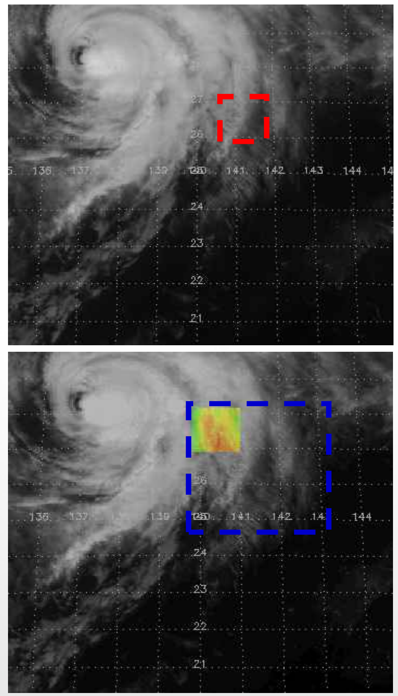
IR_AMV	WV_AMV	SWIR_AMV	VIS_AMV
EBBT	EBBT	EBBT	EBBT
STC	NTC		
IRWV	NTCC		
LLC			

Simulated T, q, U, V by NWP model (UM)

Vector derivation within Search Area determined dynamically

Quality Control (EUMETSAT QI)

Final AMVs extraction



Validation Strategy

AMV output
(QI ≥ 0.85)

Radiosonde
Wind
Observation

According to standards recommended by CGMS
(Coordination Group for Meteorological Satellites)
all AMVs which are assigned within

time difference	: **1 hour**
horizontal distance	: **150 km**
vertical level difference	: **25 hPa**
wind speed difference	: **30 ms^{-1}**
wind direction difference	: **90°**

from RAOB will be collocated

Validate AMVs with RAOB
without Spatial or Temporal Interpolation

$$RMSE_{vector} = \sqrt{\frac{1}{N}\sum\left\{(U_{AMV} - U_{sonde})^2 + (V_{AMV} - V_{sonde})^2\right\}}$$

$$BIAS_{speed} = \frac{1}{N}\sum\{WS_{AMV} - WS_{sonde}\}$$

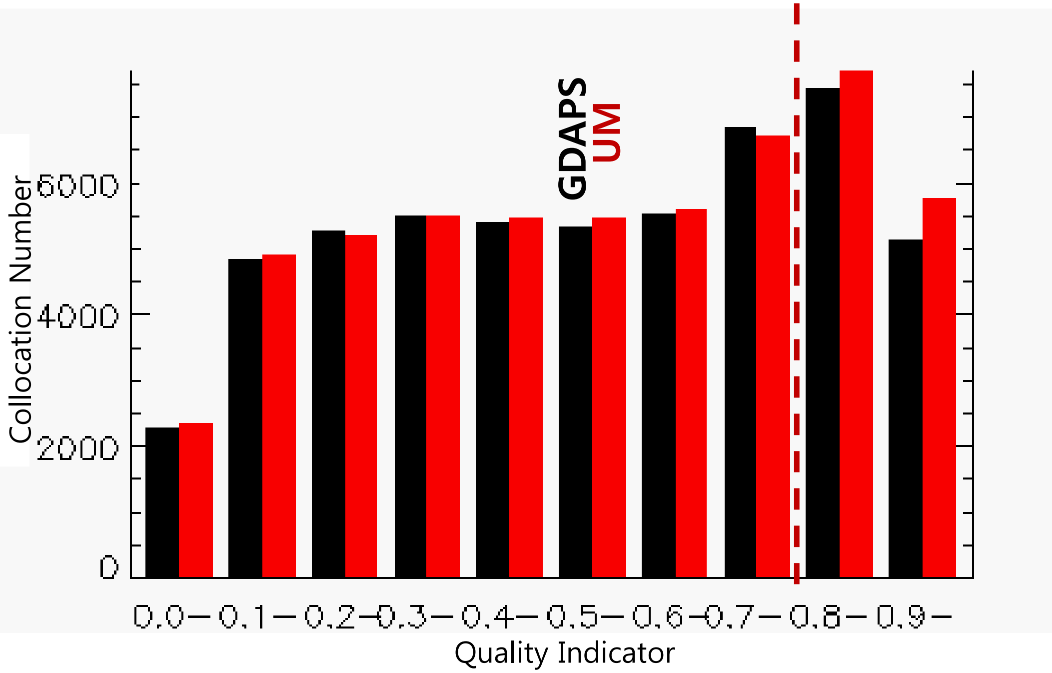
nimr

Sensitivity Tests

nimr
National Institute of Meteorological Research

Impact of UM on AMVs

- KMA's operational NWP model was switched to Unified Model (UM) from Global Data Assimilation and Prediction System (GDAPS) in 2010 and the impact of NWP switch was evaluated
- The accuracy and quality of AMVs derived with UM background is better than with GDAPS

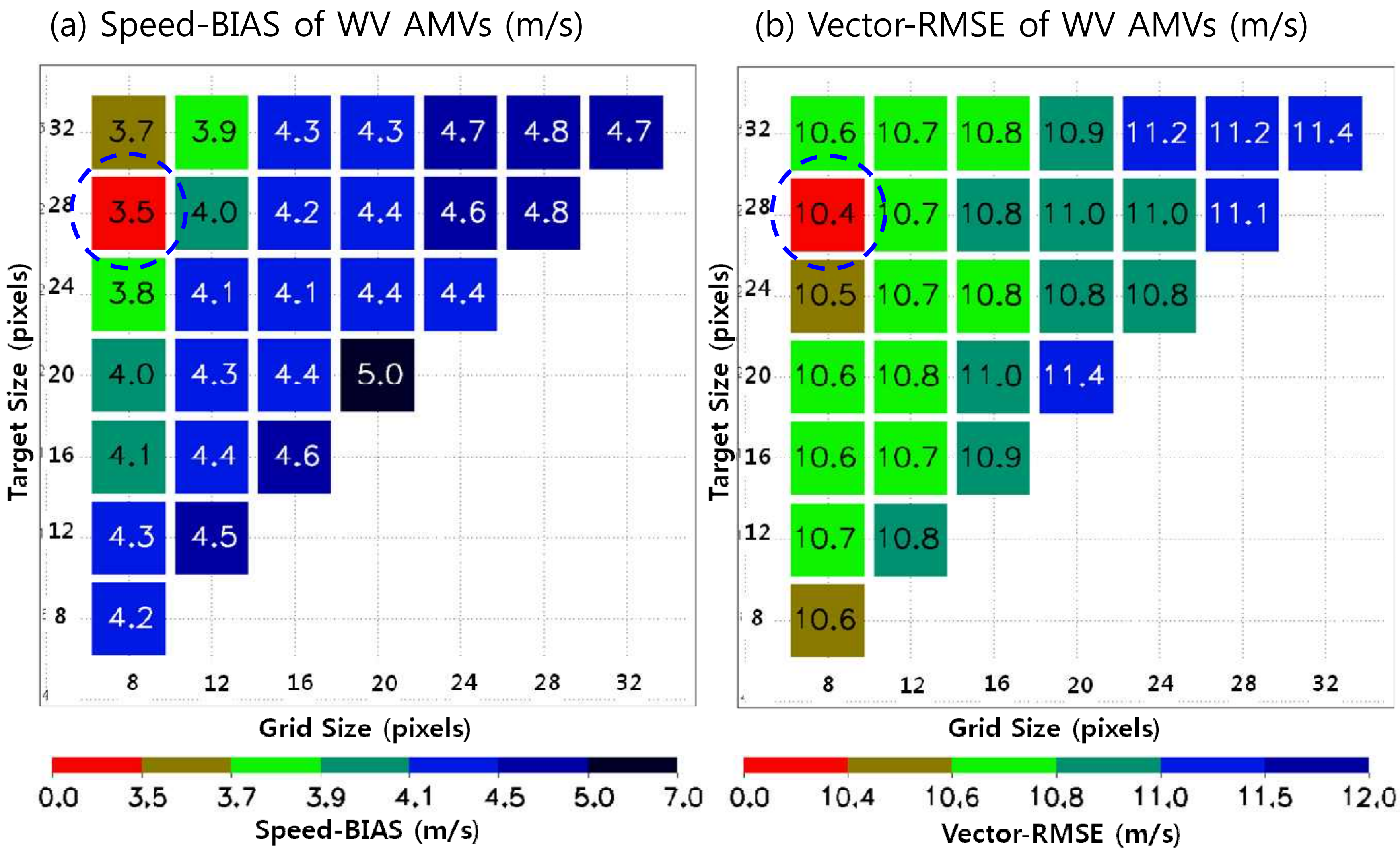


IR AMVs	GDAPS	UM
Speed-BIAS	-2.78 m/s	**-2.53 m/s**
Vector-RMSE (normalized)	8.50 m/s (0.31)	**8.19 m/s (0.31)**
Number of collocated vectors	8661	**9587**

IR AMVs, 00UTC Feb. 2010 (QI ≥ 0.85)

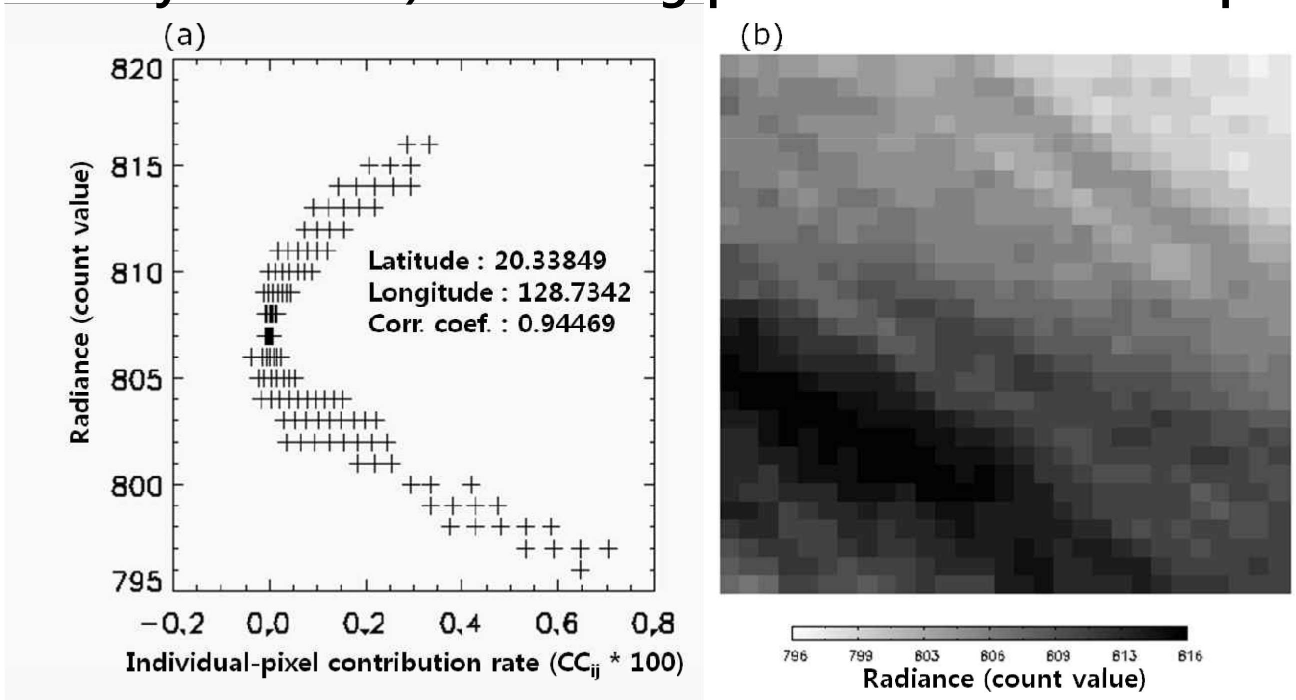
Target and Grid Size for WV AMVs

Time Interval of Satellite Image : 15 minutes (Feb. 2010)
>> Bias : 3.5~5.0 m/s , Vector-RMSE : 10.4~11.4 m/s



Pixel Selection Approach in HA (WV AMVs)

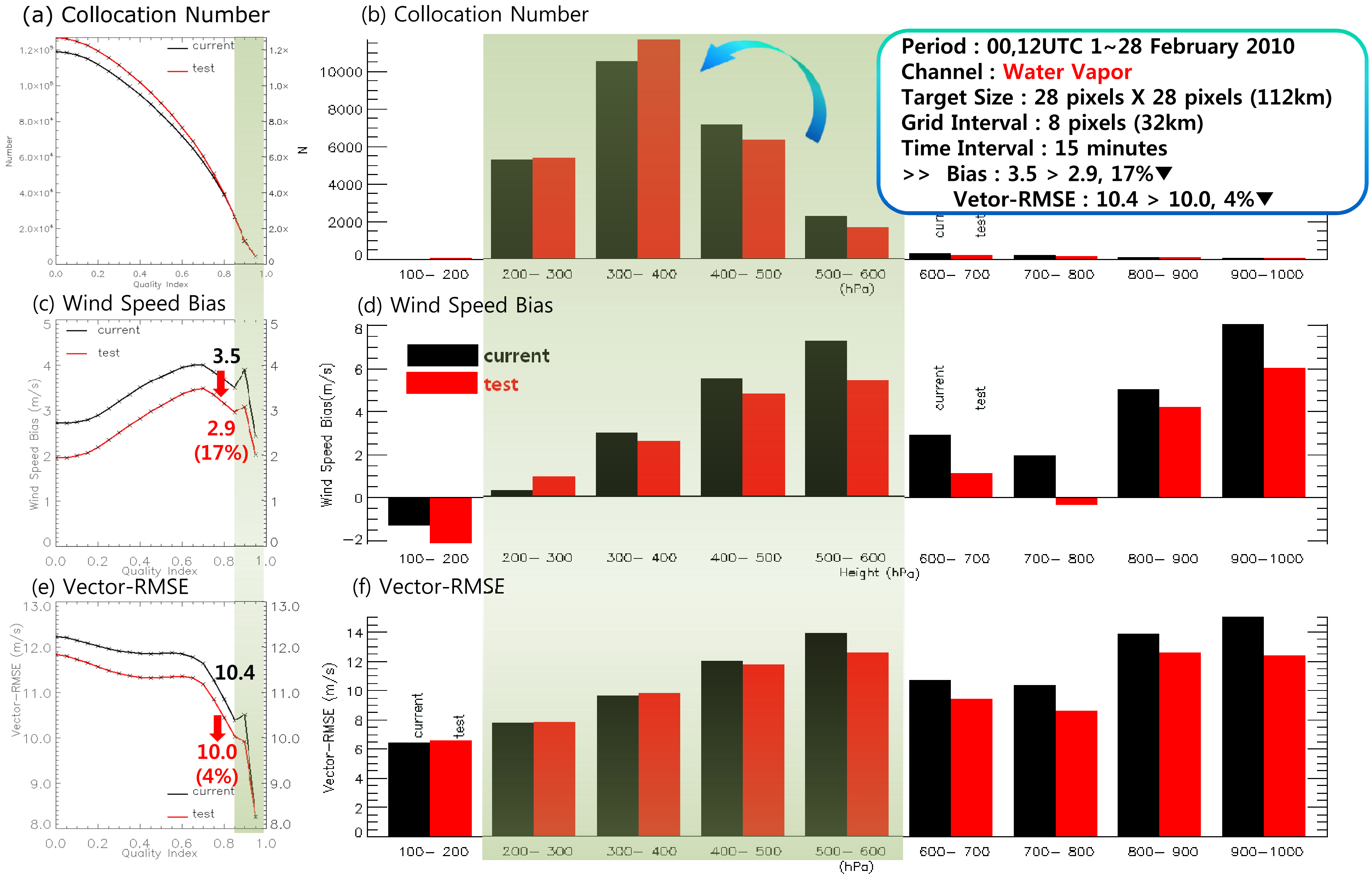
- The current algorithm uses the radiance of the coldest pixels (15%) as the representative value of the target to estimate the AMV height
- The current approach has comparatively good performance for cirrus cloud
- The current pixel selections could lead HA errors because template image used for feature-tracking contains various cloud types
- NIMR uses the individual-pixel contribution rate (Büche et al. 2006, Borde and Oyama 2008) to tracking process in order to improve this pixel selection method



$$cc(m,n) = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{A_{i+m,j+n}-\bar{A}(m,n)}{\sigma_B(m,n)}\frac{B_{ij}-\bar{B}}{\sigma_B} \equiv \sum_{i,j}^{M,N}\boxed{cc_{ij}(m,n)}$$

$$L \equiv \frac{1}{\sum_{i,j}^{pixels\ in\ target} CC_{ij}} \sum_{i,j}^{pixels\ in\ target} L_{i,j}^{cor} \times CC_{ij}$$

Results from the New Pixel Selection Approach



Period : 00,12UTC 1~28 February 2010
Channel : Water Vapor
Target Size : 28 pixels X 28 pixels (112km)
Grid Interval : 8 pixels (32km)
Time Interval : 15 minutes
>> Bias : 3.5 > 2.9, 17%▼
Vetor-RMSE : 10.4 > 10.0, 4%▼

Optimal Conditions of AMV Algorithm

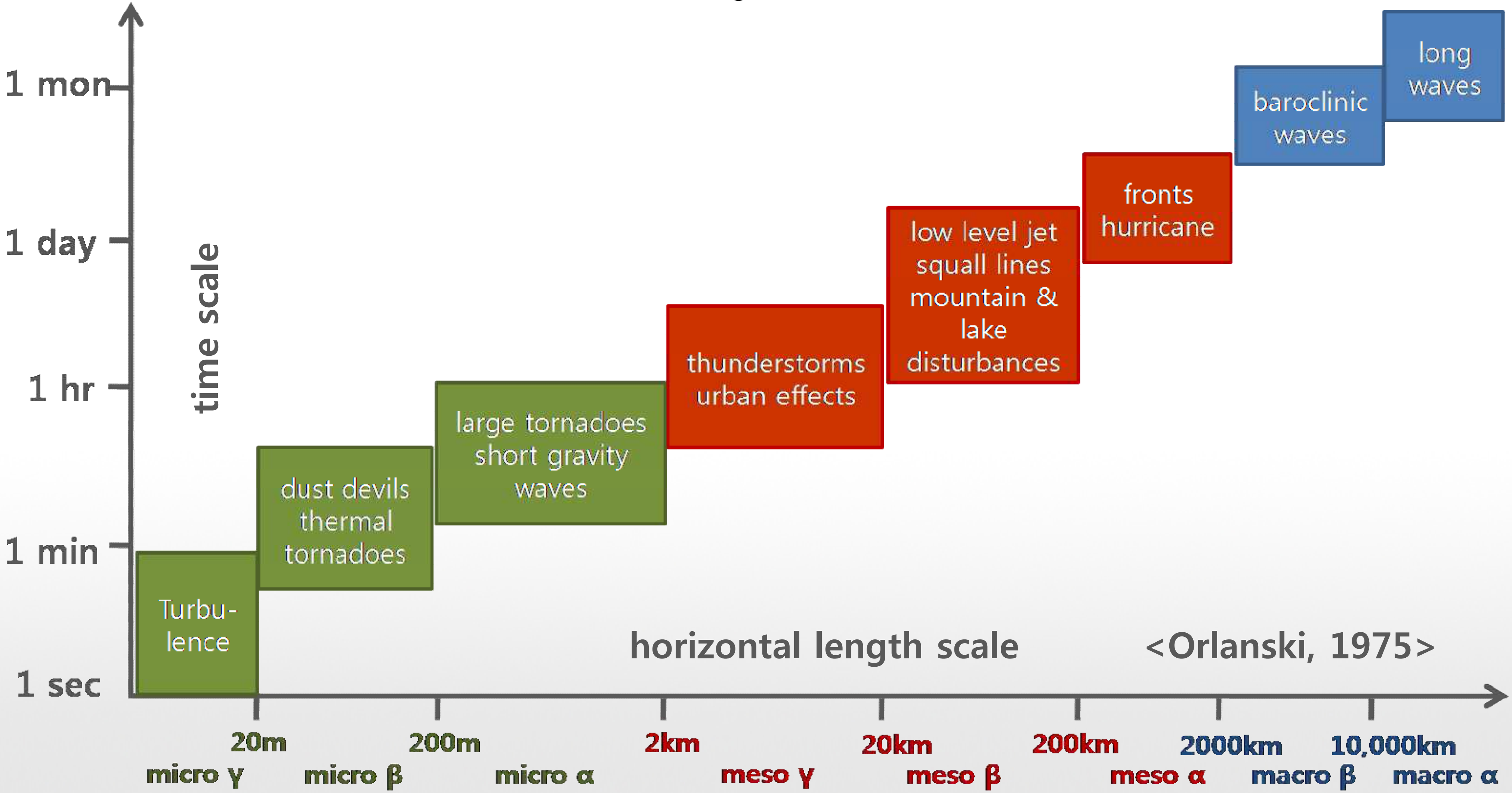
	IR AMV	**WV AMV**
NWP model	Unified Model	
Search areas	Moving search area using NWP winds	
Time interval between satellite images	15-minute	
Target classification	Cloud scene analysis	Cloud scene analysis, CTP
Target size (km)	32 X 32	**112 X 112**
Grid size (km)	32 X 32	**32 X 32**
How to decide the location of target	Regular method	Optimal method
Image pattern matching	Cross-correlation (CC)	CC(clear target), EU(cloudy target)
Height assignment (HA)	EBBT, STC	NTC(clear target), EBBT(cloudy target)
Pixel selection method in EBBT HA	Coldest pixels (15%)	**Individual-pixel contribution rate**
Low level correction	Inversion height correction	-

Optimization of Mesoscale AMV Algorithm

nimr
National Institute of Meteorological Research

NIMR's Mesoscale AMV Algorithm

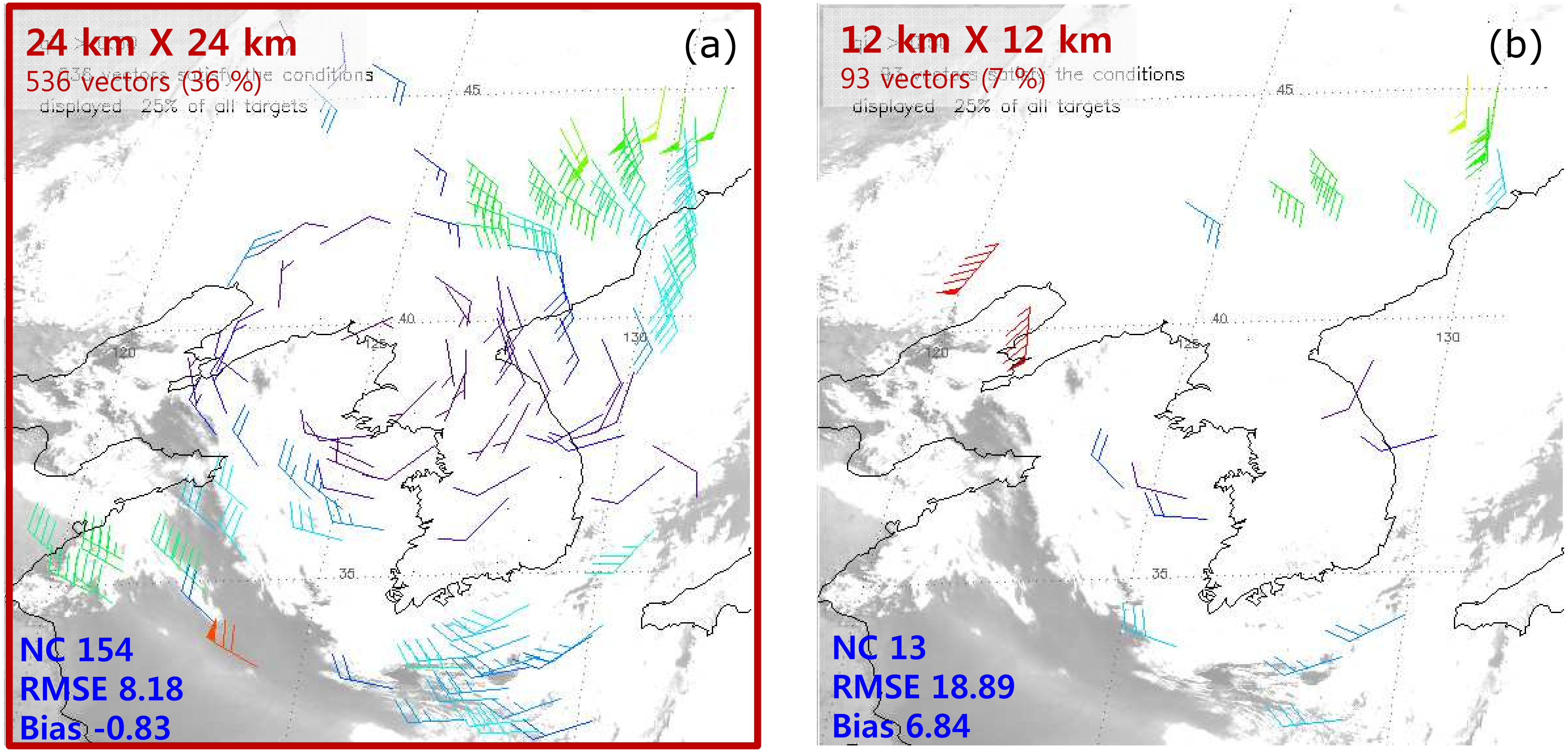
- To detect mesoscale winds such as convective clouds and ageostrophic flow smaller than synoptic-scale motion, KMA/NIMR has developed a mesoscale AMV algorithm using high resolution (1-km) visible (HRV) channel images.



NIMR's Mesoscale AMV Algorithm

- To detect mesoscale winds such as convective clouds and ageostrophic flow smaller than synoptic-scale motion, KMA/NIMR has developed a mesoscale AMV algorithm using high resolution (1-km) visible (HRV) channel images.

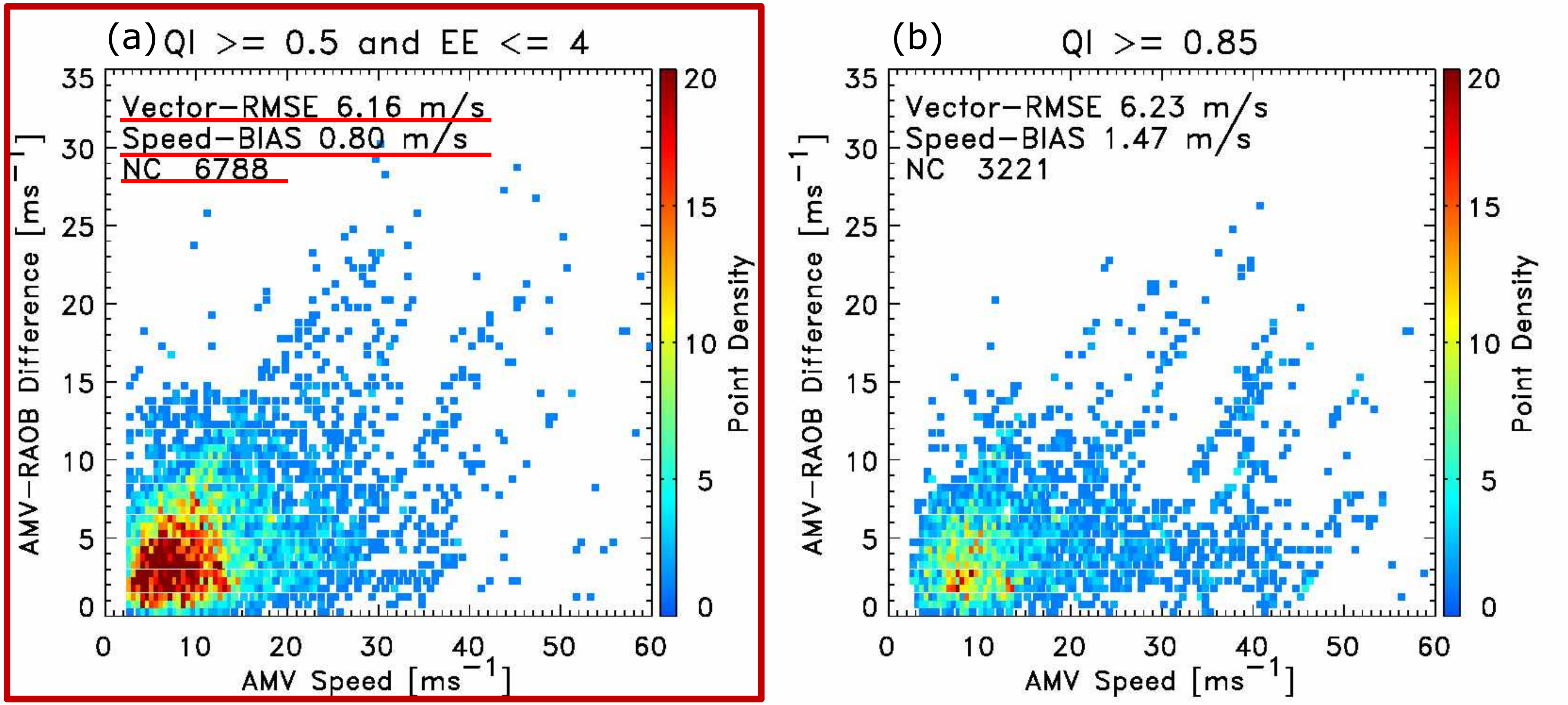
- The optimal conditions for target selection has been investigated through sensitivity tests



Quality Control for the Mesoscale AMVs

The mesoscale AMVs are expected to support nowcasting and very short-range forecasting

- **Quality Indicator (QI)** (Holmlund, 1998): 5 consistency tests (speed, direction, vector, spatial, forecast).
- **Expected Error (EE)** (Le Marshall et al., 2004): 5 QI tests + additional 4 tests (wind speed, assigned height, simulated wind shear, temperature gradient)



Cloud Base Correction for the Mesoscale AMVs

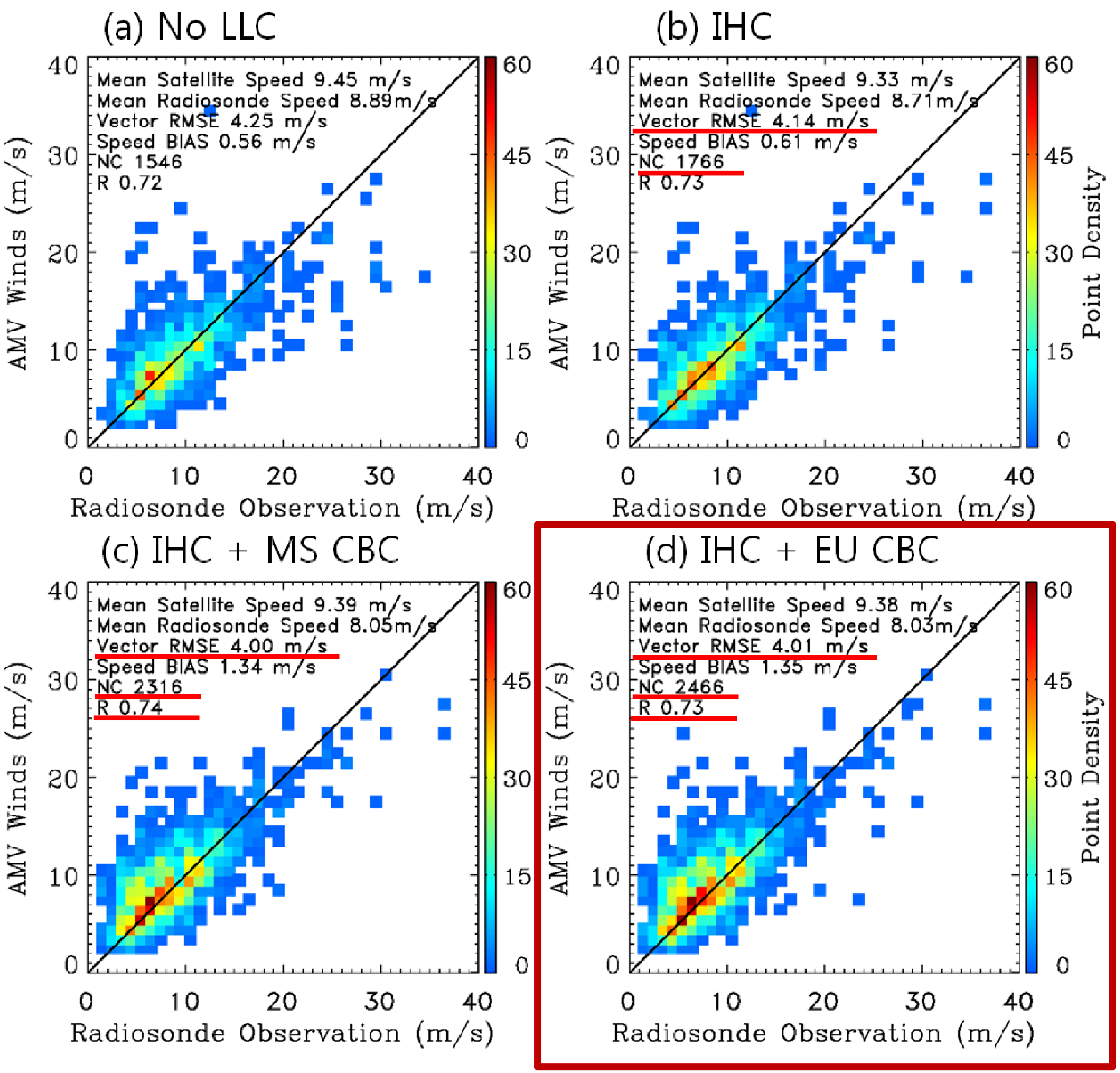
AMV heights are generally assigned to CTP, which could lead some errors for low level winds.
IHC & CBC methods could be utilized as LLC method

- **Inversion layer height correction (IHC)**
- **Cloud base correction (MS CBC)**
  * Le Marshall et al., 1994

$$T_{base} = T_{EBBT} + \sqrt{2} \cdot \sigma_T$$

- **Cloud base correction (EU CBC)**
  * EUMETSAT, 2009

$$T_{base} = T_{EBBT} + K \cdot \left[\frac{1 + \tanh \frac{(P_{EBBT} - P_{ebpt})}{Psc}}{2} \right] \cdot \sigma_T$$

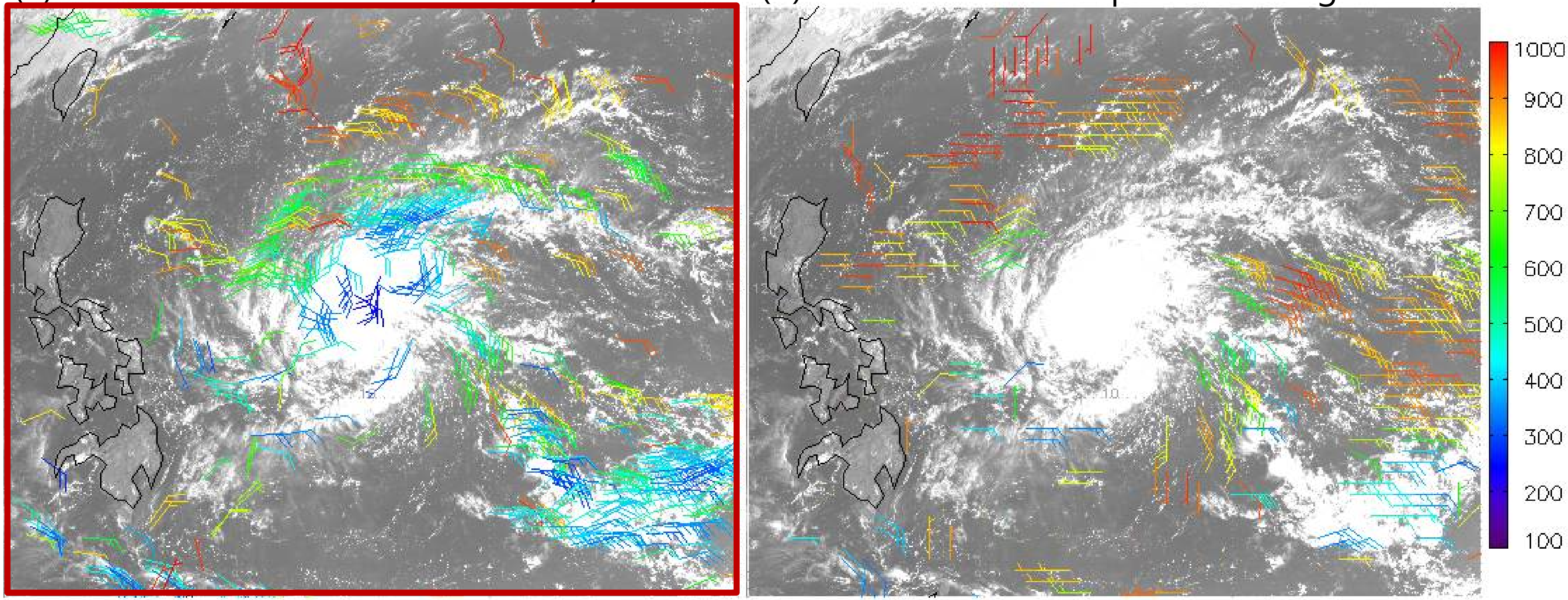


Optimal Conditions for Mesoscale AMVs

	Mesoscale (HRV)	Operational (VIS)
NWP model	Unified Model	
Resolution for scene analysis (km)	**1 X 1**	4 X 4
Search areas	Moving search area using NWP winds	
Time interval between satellite images	15-minute	
Target size (km)	**24 X 24**	96 X 96
Grid size (km)	24 X 24	48 X 48
How to decide the location of target	Optimal method	Regular method
Height assignment (HA)	EBBT	
Pixel selection method in EBBT HA	Coldest pixels (15%)	
Low level correction	**Inversion height correction, EUMETSAT cloud base correction**	Inversion height Correction
Quality Control Method	**QI ≥ 0.5 and EE ≤ 4**	QI ≥ 0.85

Mesoscale AMVs by the Optimized Algorithm

(a) Winds from mesoscale AMV algorithm (b) Winds from the operational algorithm



Comparison of mesoscale AMVs (left) and operational AMVs (right) for tropical cyclone OMAIS, 2315 UTC 23th March 2010 (QI ≥ 0.5 and EE ≤ 4).

Summary and Future Plan

- Target selection methods including target box/grid size, time interval between images, and target location method could be optimized for each channel AMVs
- The HA method with the individual-pixel contribution rate tends to improve the accuracy of WV AMVs in cloudy target
- High resolution (1-km) visible (HRV) channel images are utilized for mesoscale flows
- Mesoscale AMV algorithm has been optimized and will be applied to COMS satellite images
- The impact of the mesoscale AMVs from COMS on UM forecast will be evaluated

Thank you
for your attention

nimr
National Institute of Meteorological Research