THE DEVELOPMENT FOR MTSAT RAPID SCAN HIGH RESOLUTION AMVS AT JMA/MSC

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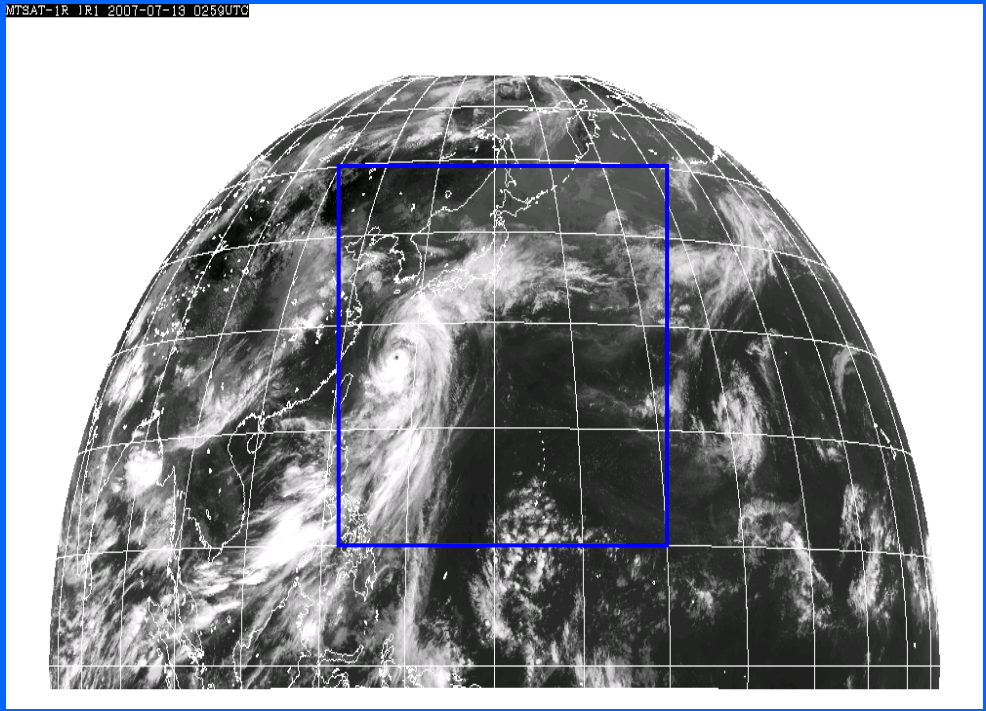
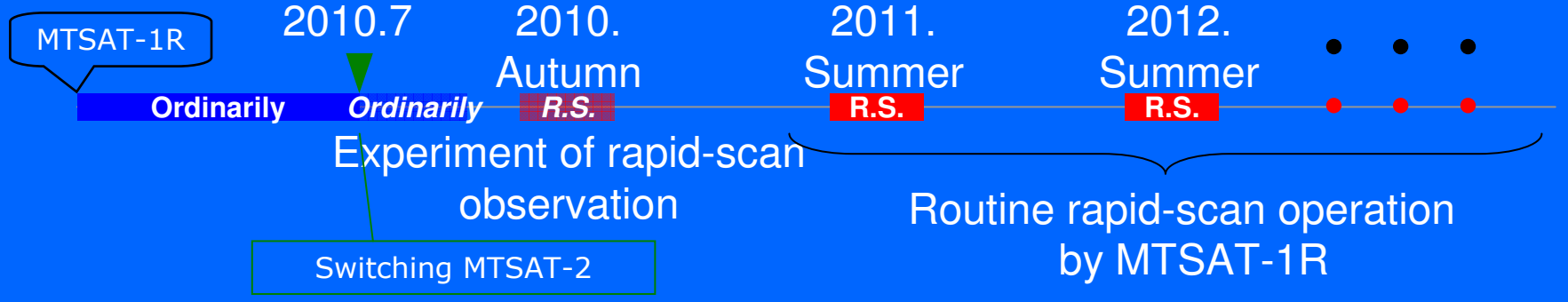
T-PARC Enhanced Observation by MTSAT-2

1. Hemisphere scan : 15min North hemisphere image
2. Rapid-scan : 7min small area image
3. Rapid-scan : 4min small area image

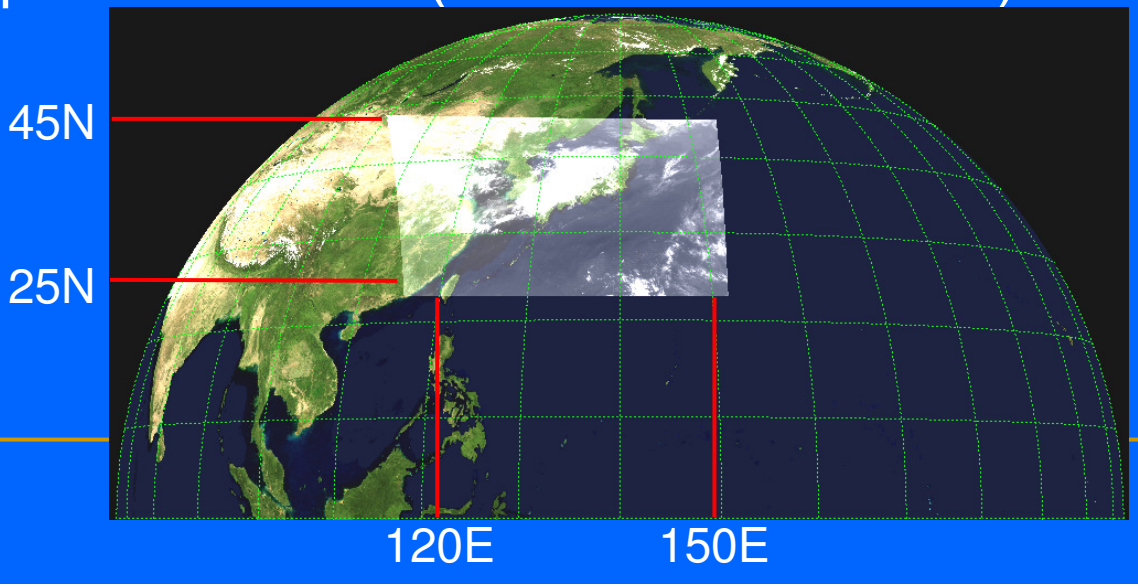


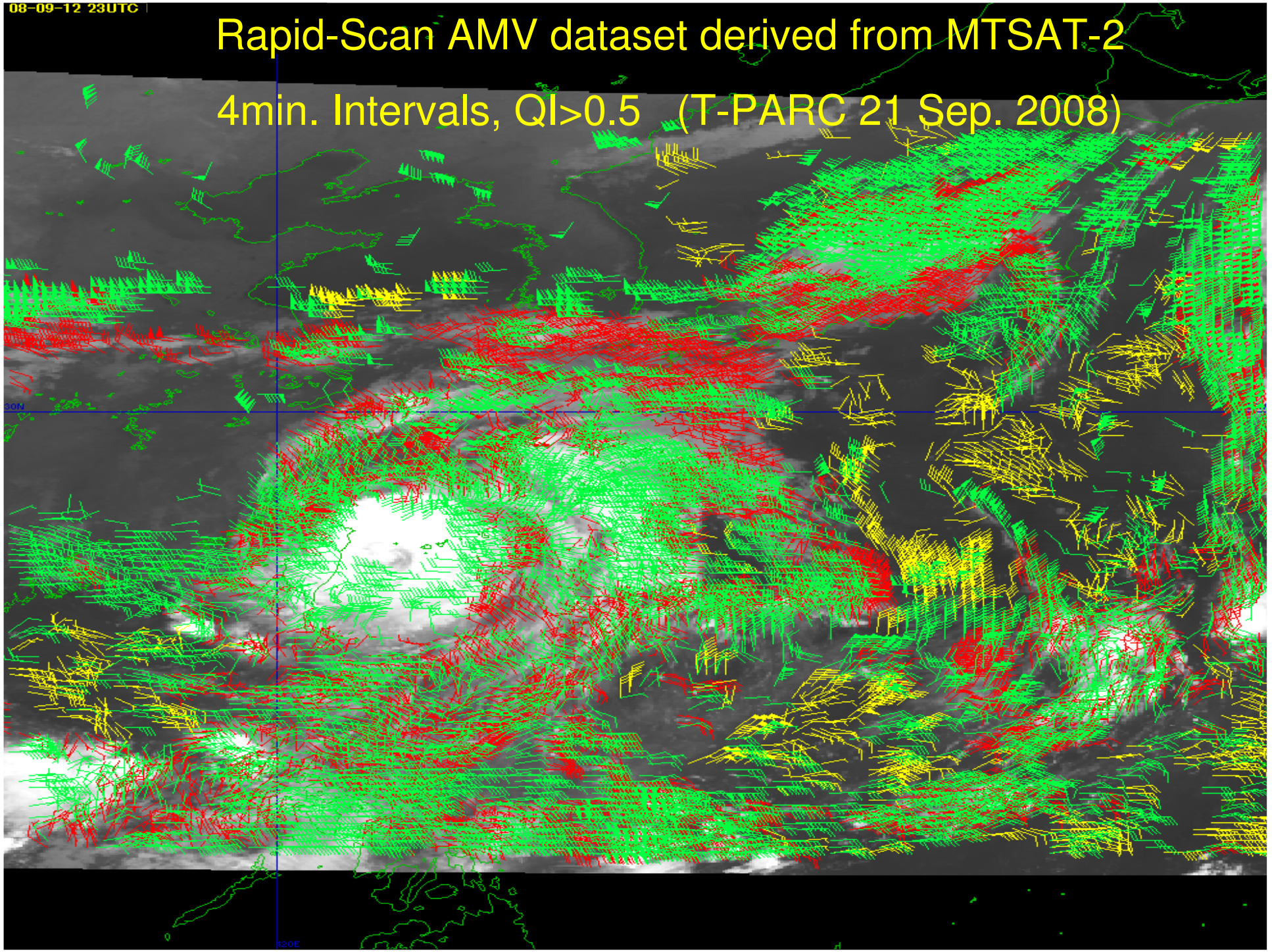
- Sep 2008 10th 12UTC - 13th 06UTC
- Sep 2008 17th 12UTC - 18th 12UTC
- Sep 2008 27th 12UTC - 28th 12UTC

Plan of Rapid-Scan observation by MTSAT-1R



Rapid-Scan Area (for 5min. intervals) ： 120-150E、25-45N




08-09-12 23UTC
Rapid-Scan AMV dataset derived from MTSAT-2
4min. Intervals, QI>0.5 (T-PARC 21 Sep. 2008)

Purpose

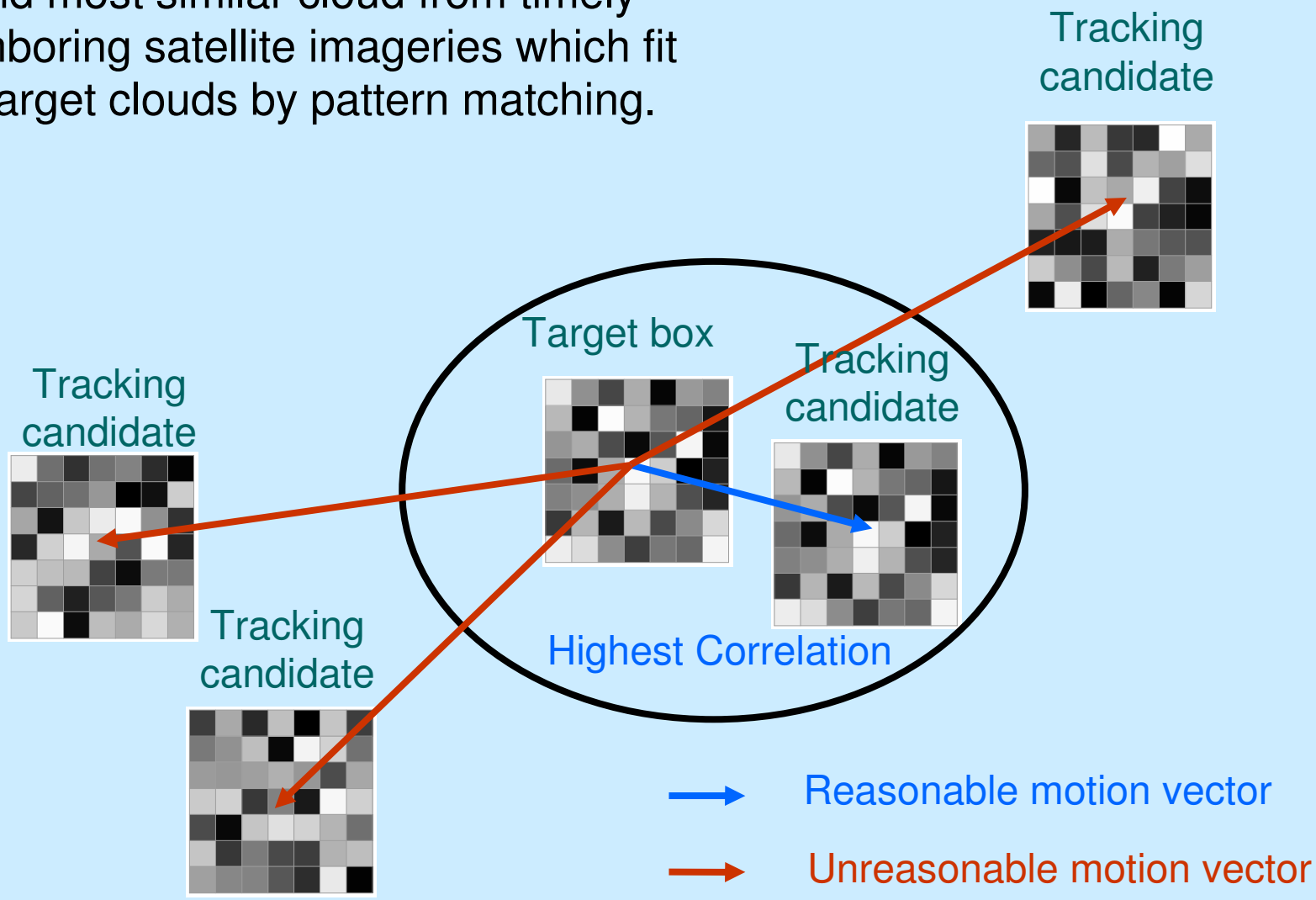
- To utilize excessive high time-resolution of satellite images by rapid-scan function as a substitute for spatial-resolution of Atmospheric Motion Vectors.

Proposal Method for the purpose

- By using not only 2 imageries but also sequentially rapid-scanned multiple satellite imageries, to cancel AMV quality loss caused from lack of number of pixels with narrowing down target box size.

Cloud Tracking Method for RTN AMVs at JMA/MSC

To find most similar cloud from timely neighboring satellite imageries which fit into target clouds by pattern matching.

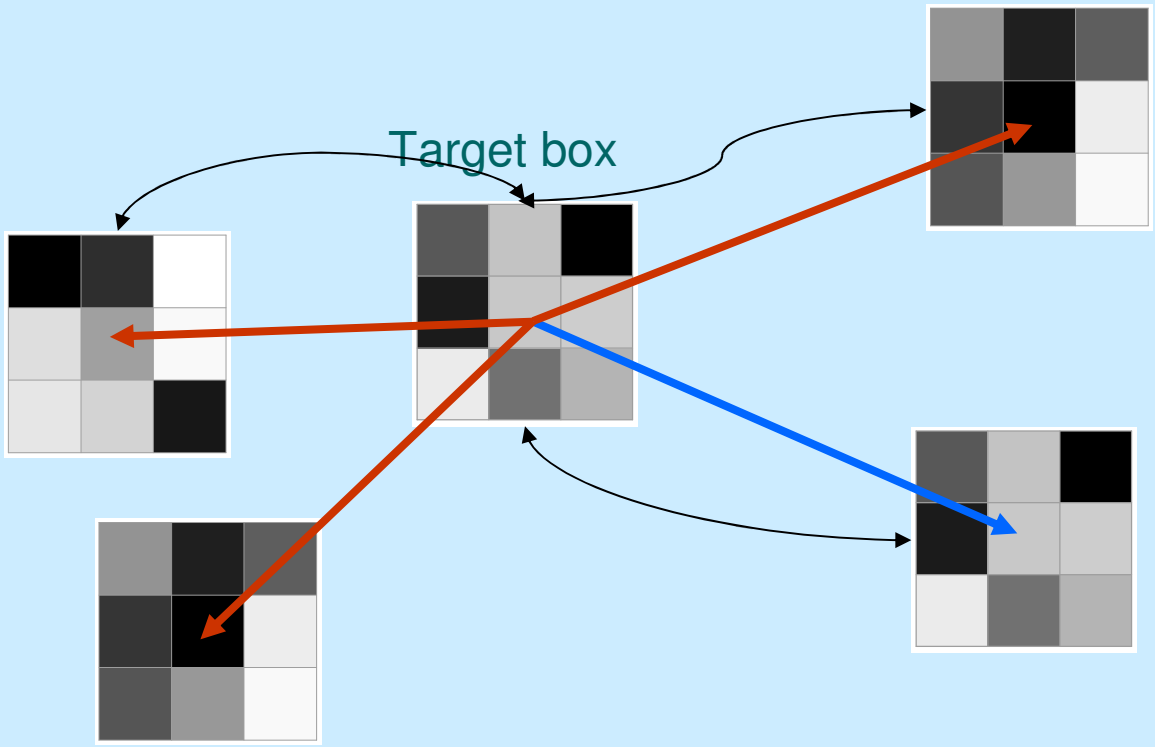


Cloud Tracking Method for RTN AMVs at JMA/MSC

Correlation coefficient between targets is not statistically reliable when sample number (target box size) is too small.

Reasonable motion vector

Unreasonable motion vector



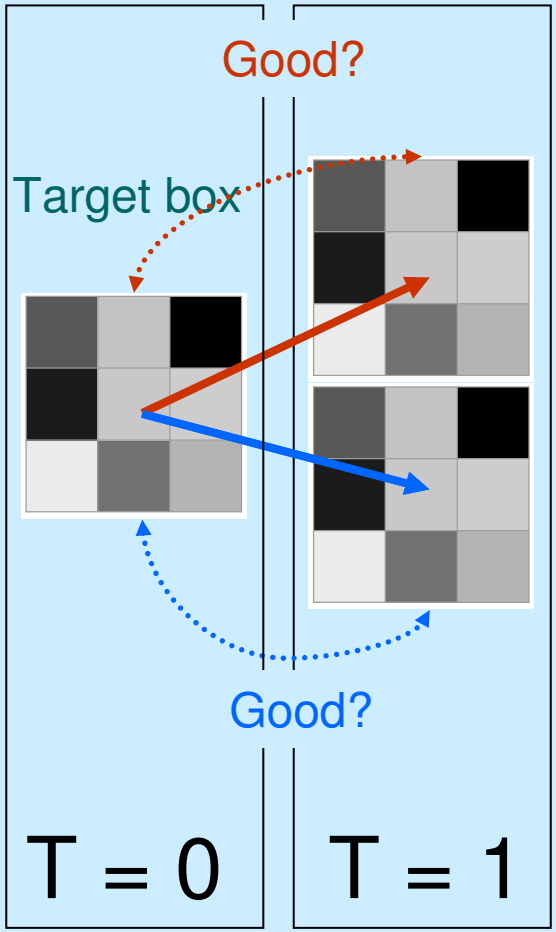
Average of correlation coefficients computed from timely neighboring targets

Reasonable motion vector

Unreasonable motion vector

Statistical significance of correlation coefficients between 2 small 3x3 pixels targets cut from satellite imageries is very bad.

1% significant level of correlation at sample number = 9 is about 0.798. It means that correlation coefficient less than 0.798 is emptiness for pattern matching on cross-correlation method.

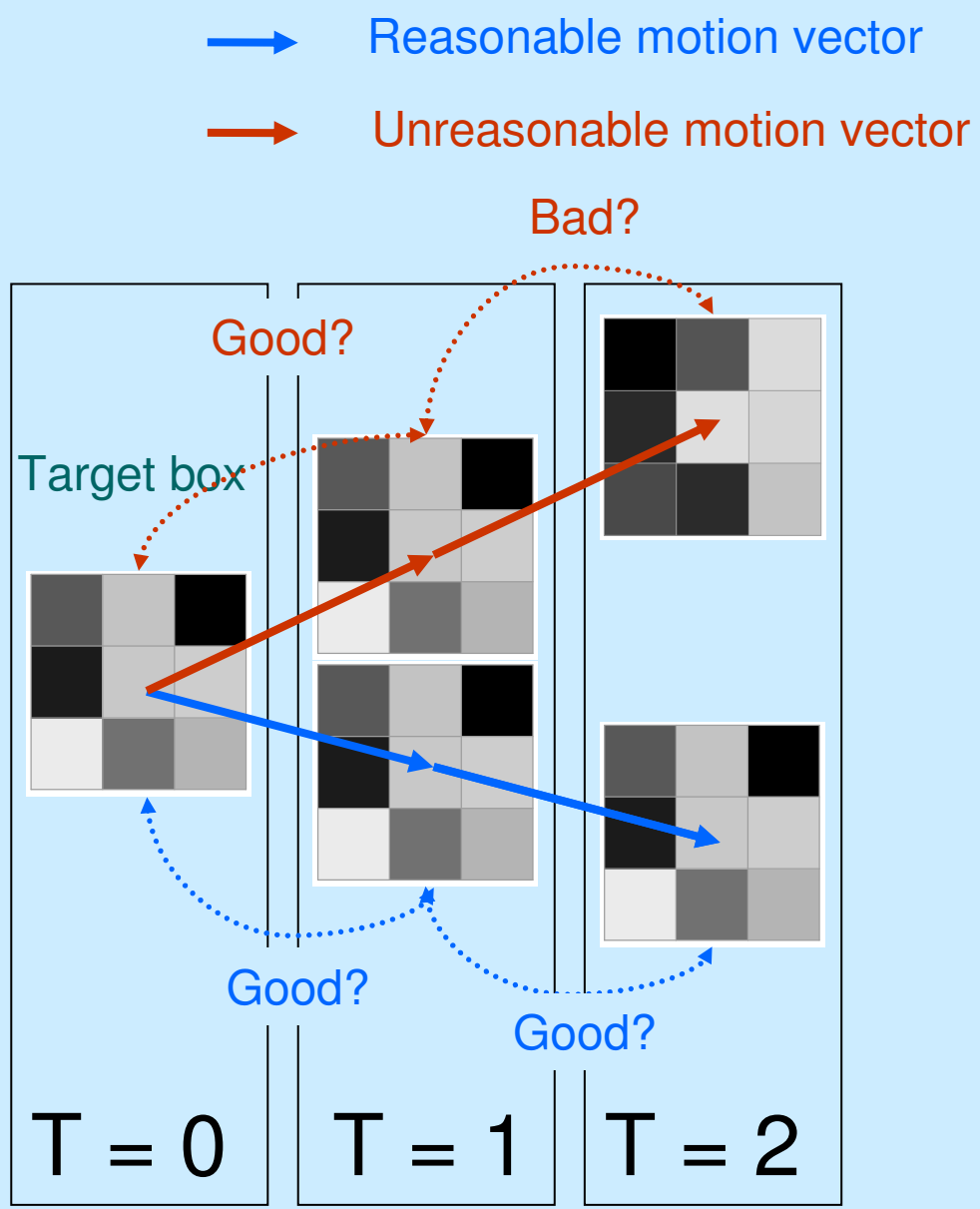


Average of correlation coefficients computed from timely neighboring targets

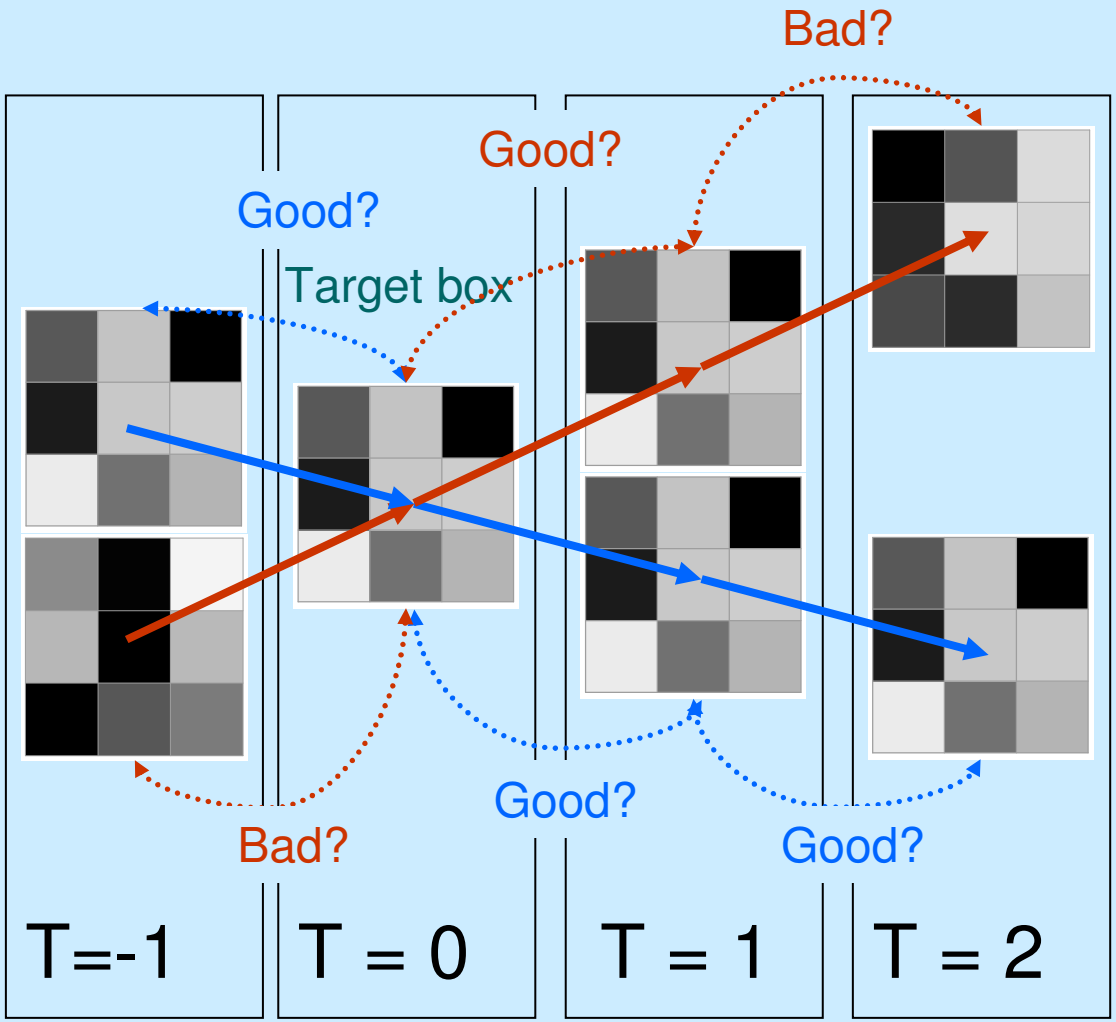
But average of uncertain quantities is generally more certain than each uncertain quantity.

In rapid-scan observation, sequence of many satellite imageries can be observed. Namely, it is able to compute correlation coefficient from not only a pair of timely neighboring imageries but also many pairs of those imageries.

Consistency of motion vector is supposed during rapid-scan.



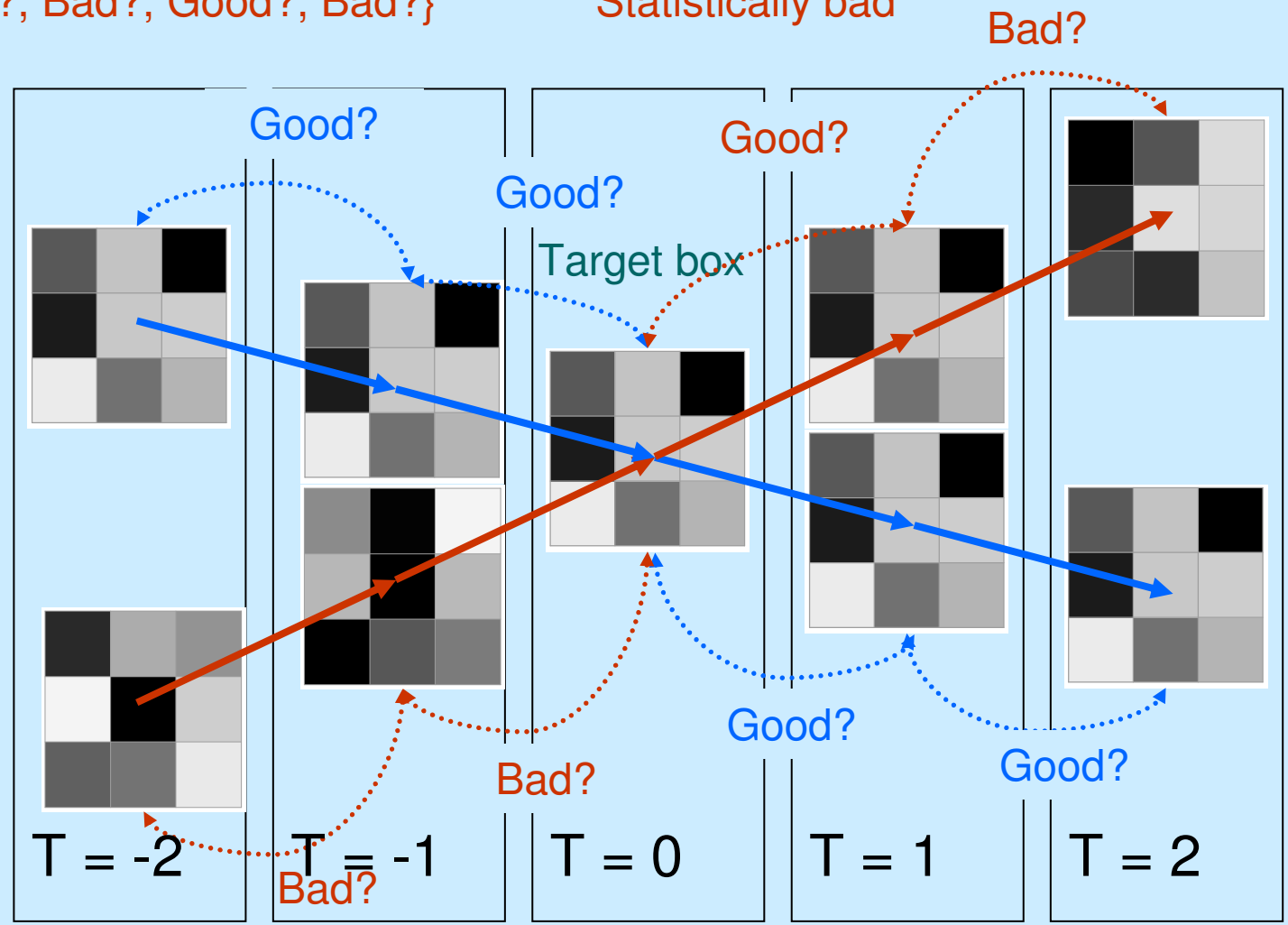
Average of correlation coefficients computed from timely neighboring targets



Average of correlation coefficients computed from timely neighboring targets

{Good?, Good?, Good?, Good?} Statistically good

{Bad?, Bad?, Good?, Bad?} Statistically bad



Average of correlation coefficients computed from timely neighboring targets

Velocity and acceleration which Maximize average of correlations $C_{mean}(\vec{v},\vec{a})$ is most likelihood velocity and acceleration of targeted cloud.

$$C_{mean}(\vec{v},\vec{a}) \equiv \cos\left(\frac{1}{N-1} \sum_{n=1}^{N-1} \cos^{-1}\left(C(I_n(\vec{r}_n), I_{n+1}(\vec{r}_{n+1})) \right) \right)$$

$$\vec{r}_n(\vec{v},\vec{a},t_n) \equiv \vec{r}_{tgt} + \vec{v}(t_n - t_{tgt}) + \frac{1}{2}\vec{a}(t_n - t_{tgt})^2$$

$C(x,y)$: Correlation coefficient of small image segments x and y

$I_n(\vec{r}_n)$: Small image segment cut from nth imagery

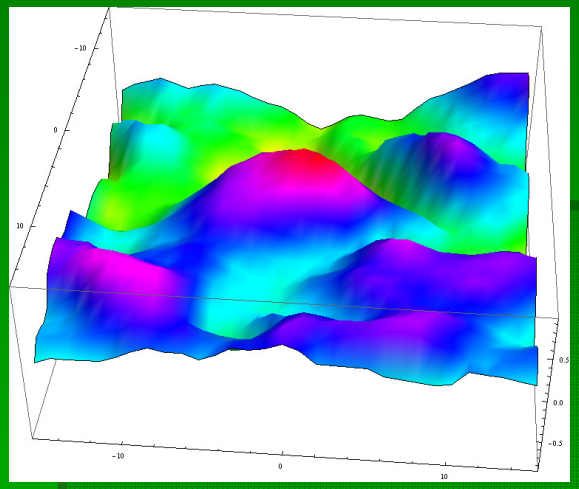
$\vec{v}$: Target velocity

$\vec{a}$: Target Acceleration

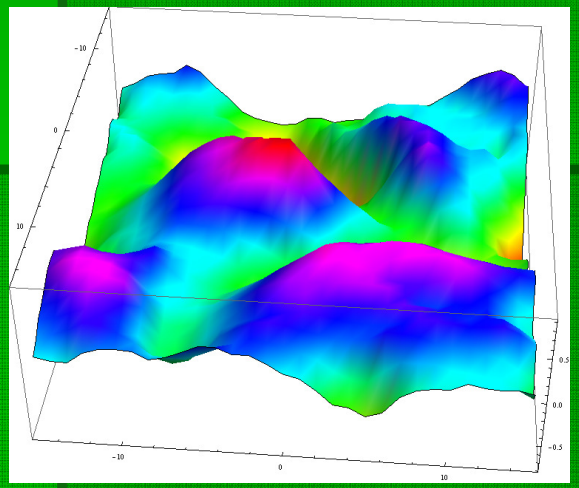
t_n : Time nth imagery observed

$\vec{r}_n$: Target position on nth imagery

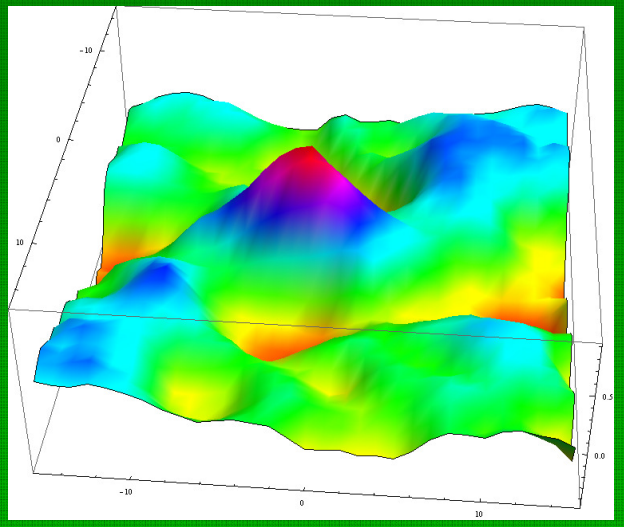
Effect of averaging operation for matching surfaces (9x9)



Matching surface from forward motion



Matching surface from backward motion

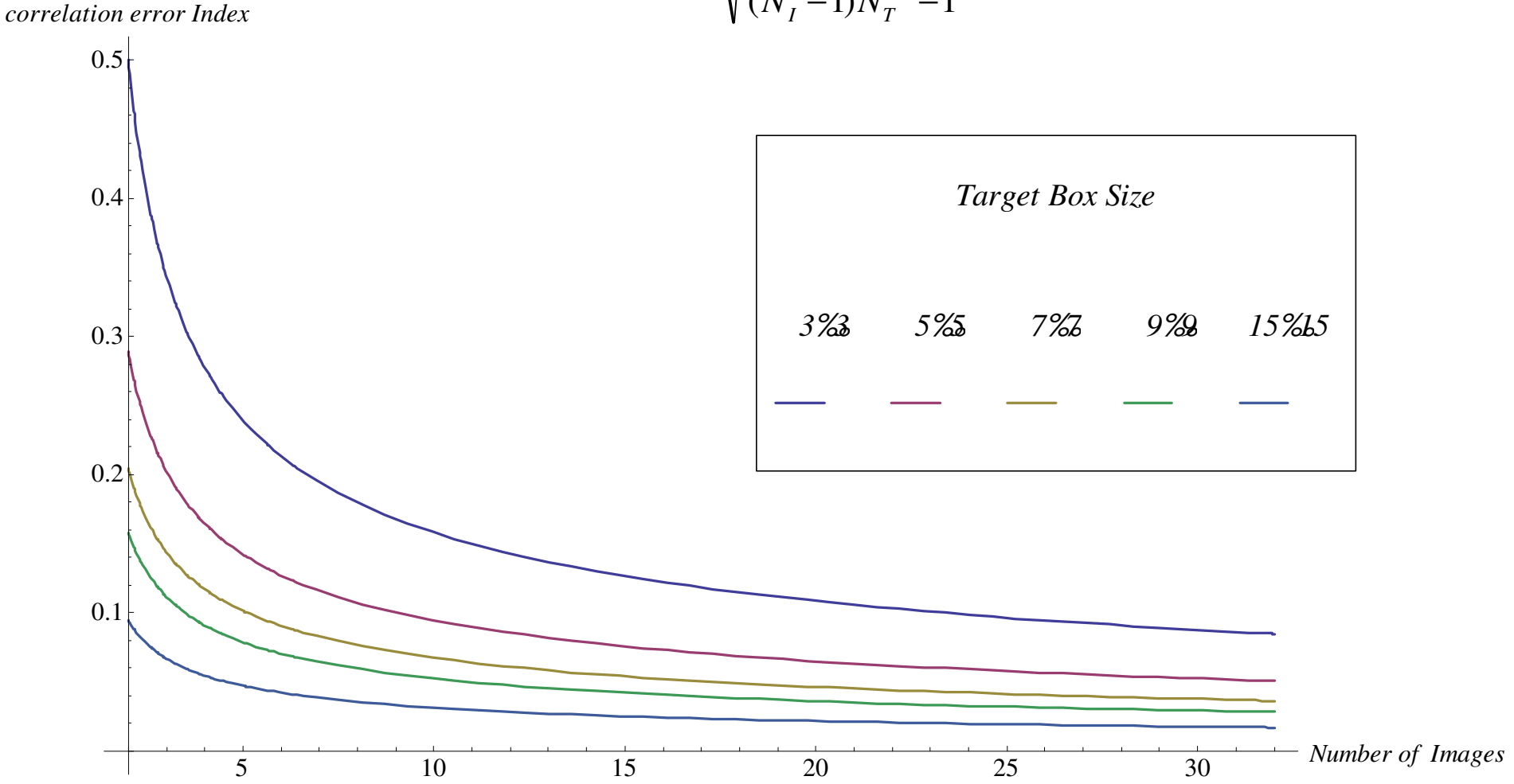


Average of matching surface from the 2 matching surface

Peak (=likelihood target velocity) on average of 2 matching surfaces is clearer than each peak derived from 2 imageries.

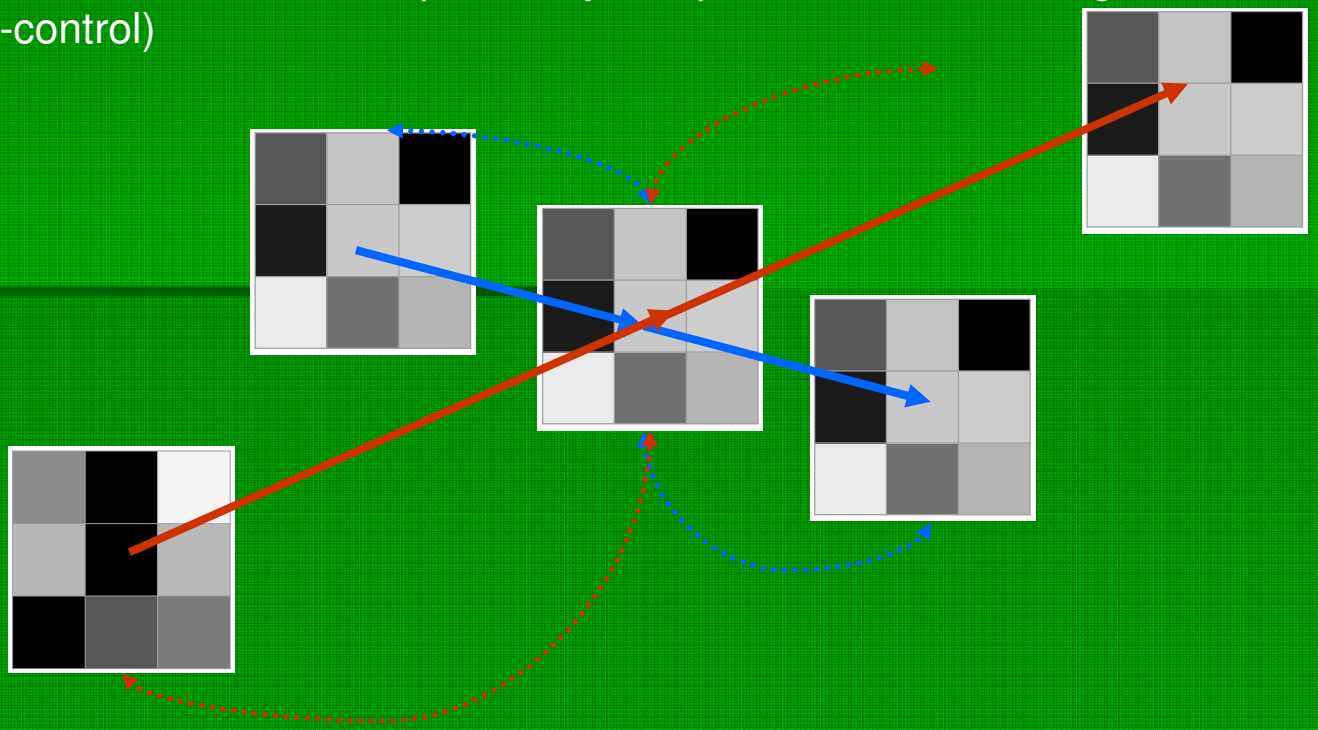
Correlation Error Dependency on Target Box Size

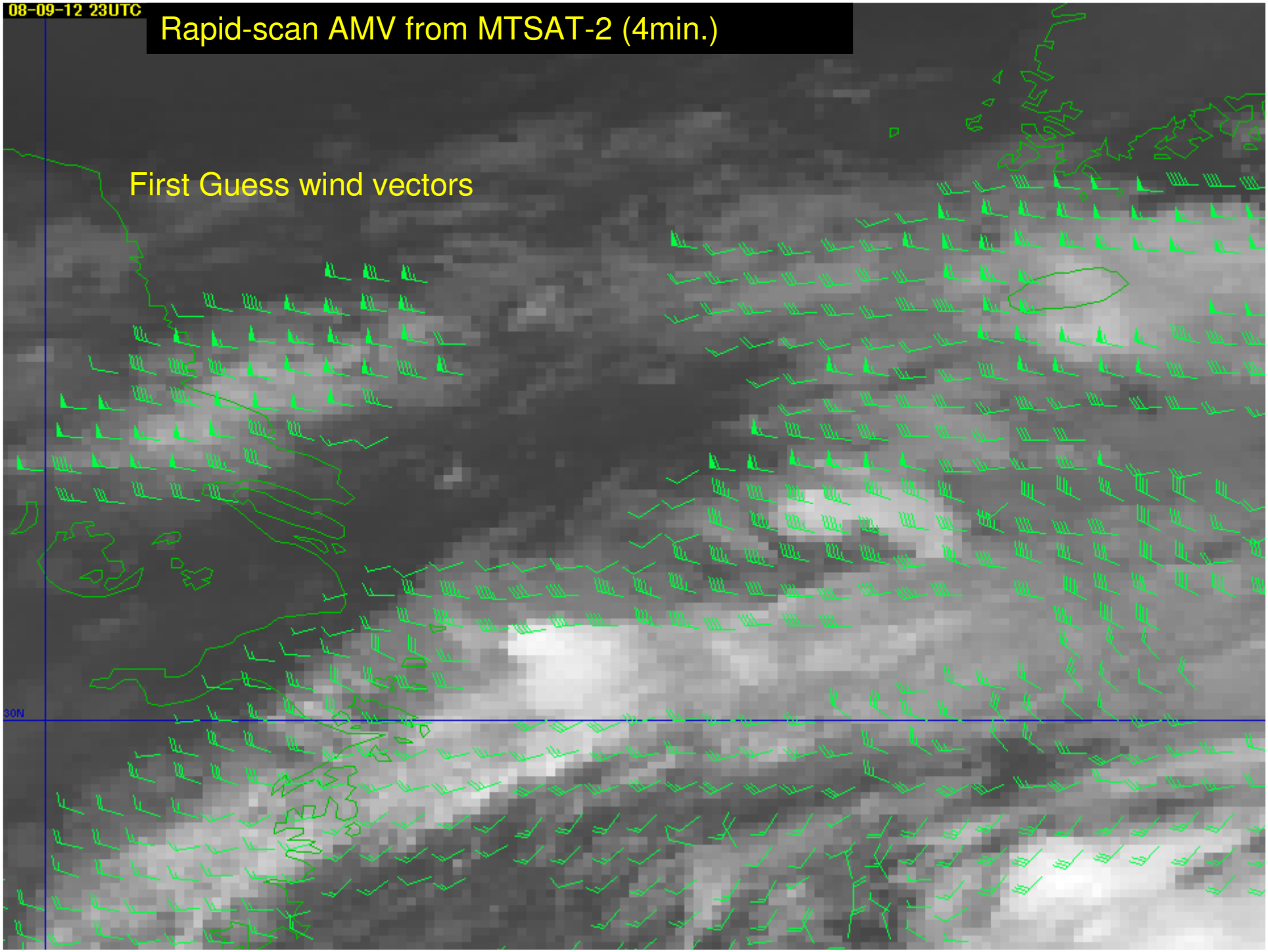
$$Corr\_error\_index \equiv \sqrt{\frac{c^2+1}{(N_I-1)N_T{}^2-1}}$$

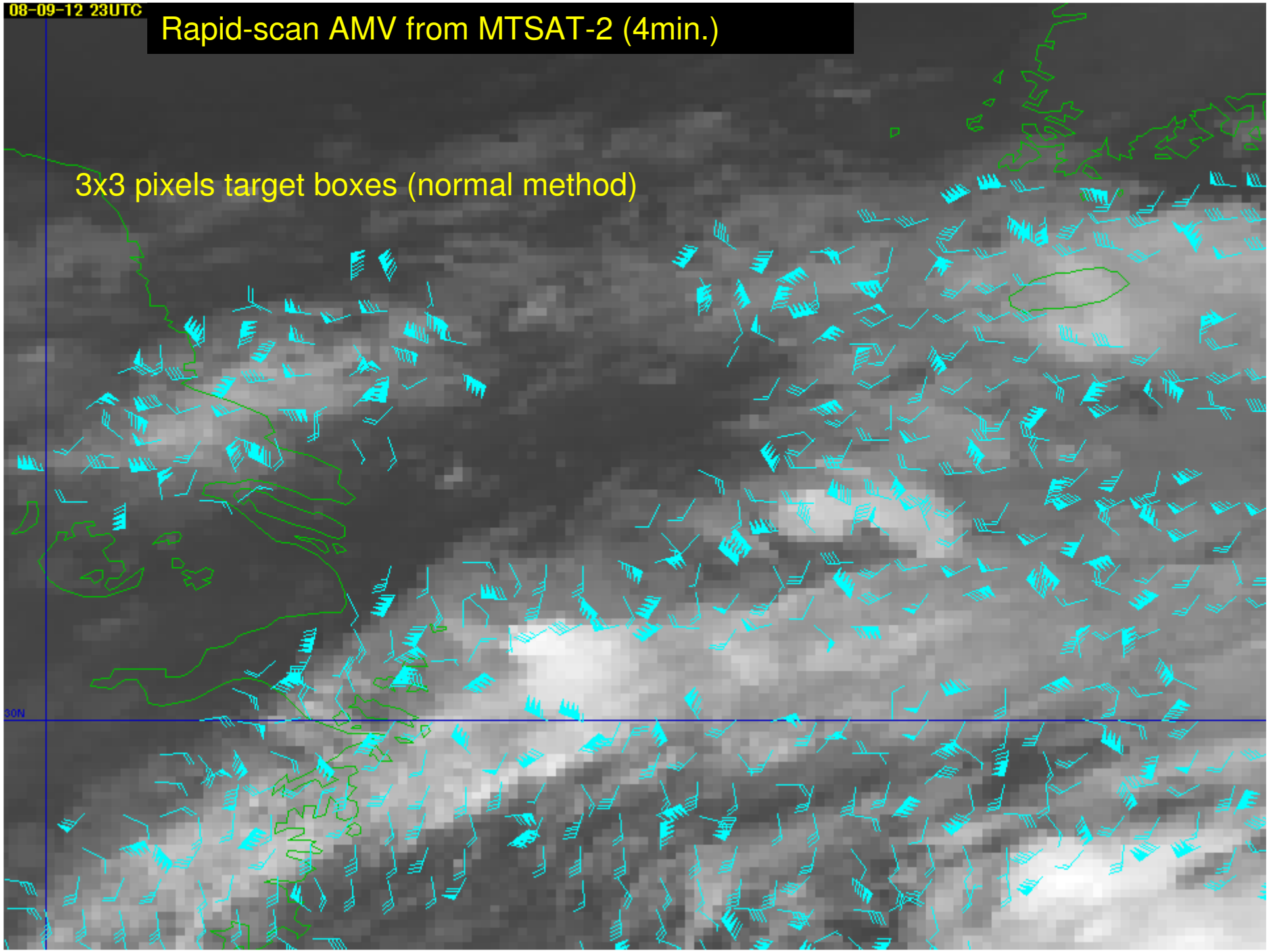


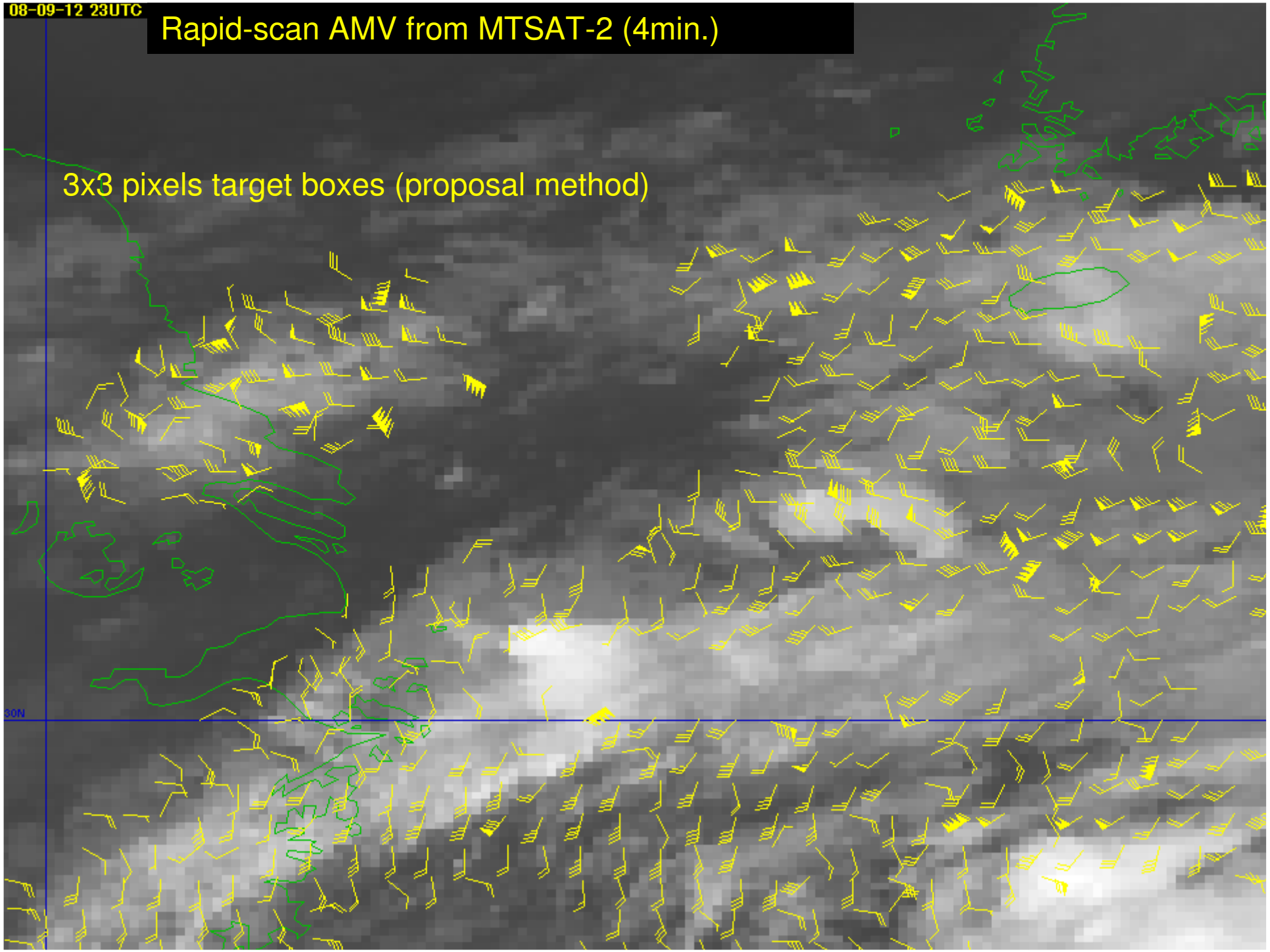
Average of correlation coefficients computed from timely neighboring targets

- Used satellite images are rapid-scanned by MTSAT-2 for THORPEX T-PARC campaign on September 2008
- Target box size is 3x3 for seeing effect by proposal method.
- Time-resolution of rapid-scan imageries are about 4min.
- Continuous 3 imageries are utilized for the experiment. acceleration search is not done.
- Quality control by QI is not available for this experiment because it is needed to compare 2 wind vectors independently computed. 5 or more imageries are needed for quality-control)

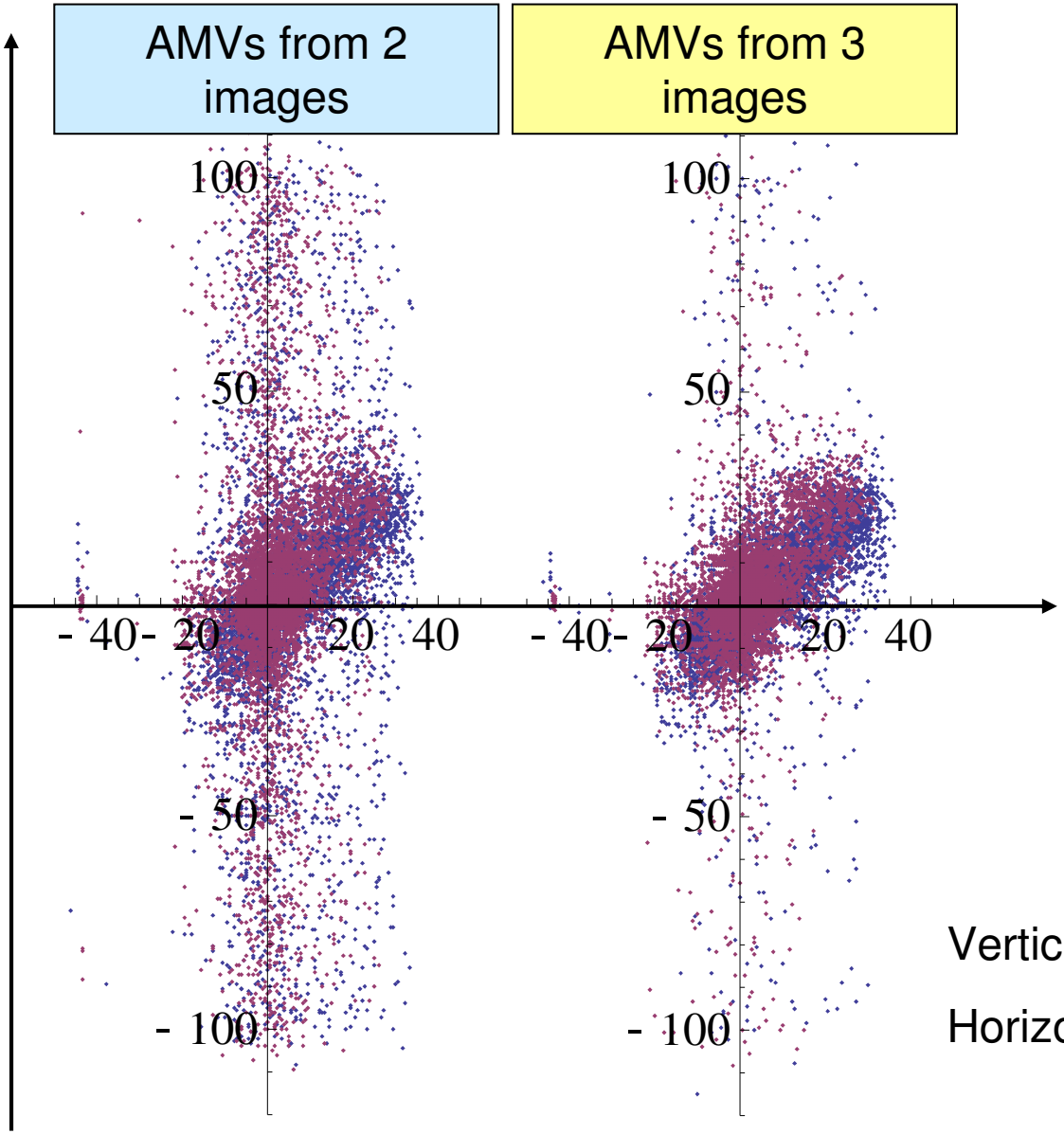



08-09-12 23UTC
Rapid-scan AMV from MTSAT-2 (4min.)
First Guess wind vectors
30N


08-09-12 23UTC
Rapid-scan AMV from MTSAT-2 (4min.)
3x3 pixels target boxes (normal method)
30N


08-09-12 23UTC
Rapid-scan AMV from MTSAT-2 (4min.)
3x3 pixels target boxes (proposal method)
30N

Comparison between AMVs(3x3) and First guess



Target Box Size = 3x3 pixels

Blue :: u component of wind

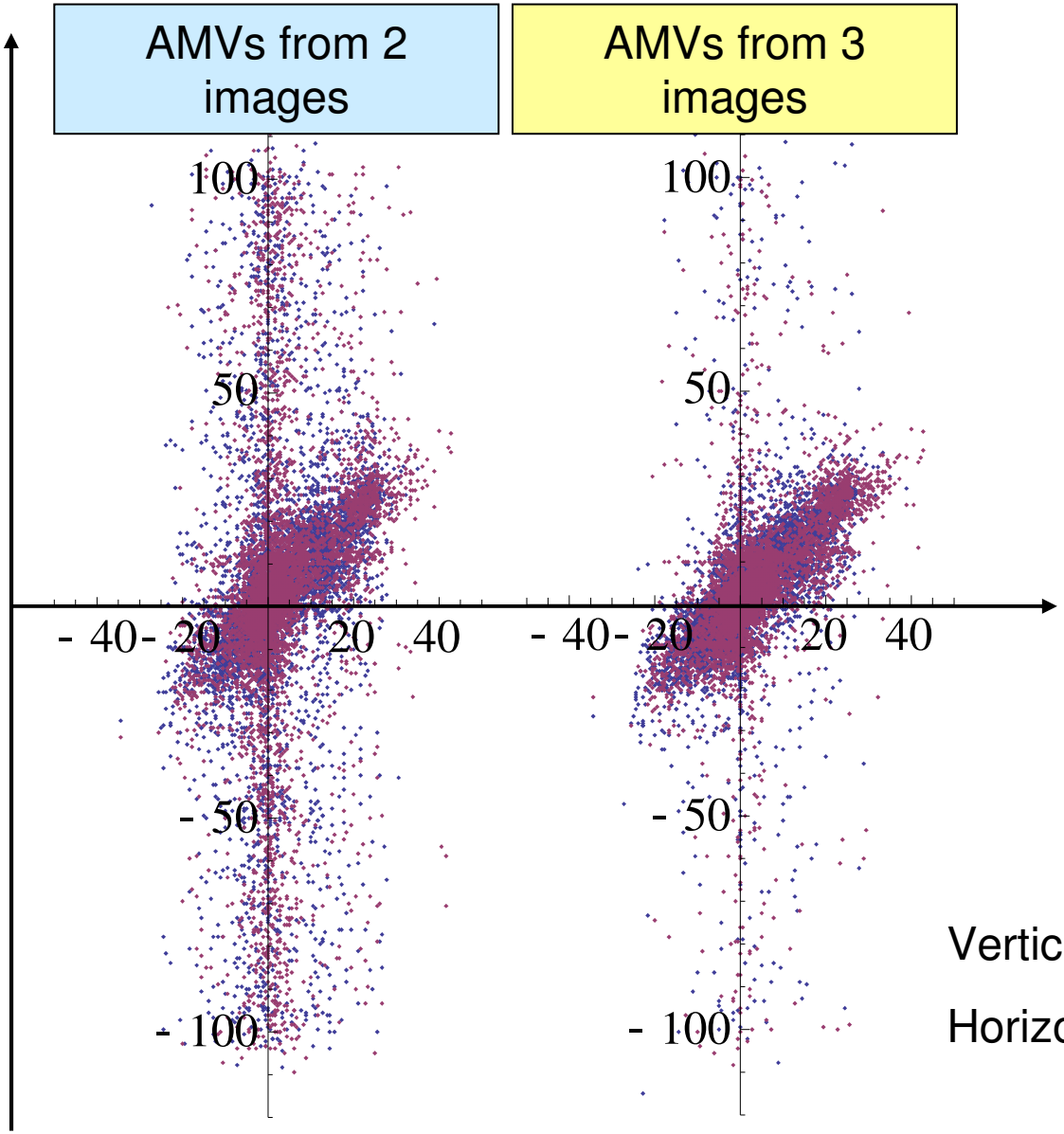
Red :: v component of wind

AMVs(3x3) VS FG wind	2 images	3 images
U Correlation	0.200	0.371
V Correlation	0.174	0.377
BIAS (u_3-u_fg)	-1.635	-0.680
BIAS (v_3-v_fg)	0.660	0.657
SD (u_3-u_fg)	30.424	18.610
SD (v_3-v_fg)	29.808	14.991

Vertical axes :: AMV (3 x 3)(m/s)

Horizontal axes ::First guess (m/s)

Comparison between AMVs(3x3) and AMVs(16x16,normal)



Blue :: u component of wind

Red :: v component of wind

AMVs(3x3) VS AMVs(16x16)	2 images	3 images
U Correlation	0.258	0.513
V Correlation	0.248	0.504
BIAS (u_3-u_16)	-0.646	0.309
BIAS (v_3-v_16)	0.051	0.049
SD (u_3-u_16)	28.060	14.146
SD (v_3-v_16)	29.155	13.769

Vertical axes :: AMV (3 x 3)(m/s)

Horizontal axes :: AMV (16x16)(m/s)

Summary of comparison

- In case of small target box size (3x3), AMVs derived by the proposal method shows superiority compared with normal method which is using just 2 images for one AMVs dataset. Correlation, BIAS and standard deviation against first-guess-wind and AMVs(16x16) by normal method are dominantly decreased.

Conclusions

- On comparison to NWP wind, Experimentally derived AMVs from sequential 3 imageries shows better result than that from 2 imageries.
- The proposal method has a potential to convert extra time-resolution of rapid-scan-observation into high spatial-resolution of AMVs dataset.

Rapid scan AMVs should be derived from animation, not from picture-card show.

Future Plan

- To apply Quality Control by QI to the AMVs derived by proposal method. at least 5 or more imageries are required for QC.

- MSC is planning to increase rapid-scan-observations. Continuously rapid-scanned 24 imageries (5 min. intervals) has been available since last week. AMVs from 3 or more imageries will be utilized for second experiment.

END

Thank you for your attention.

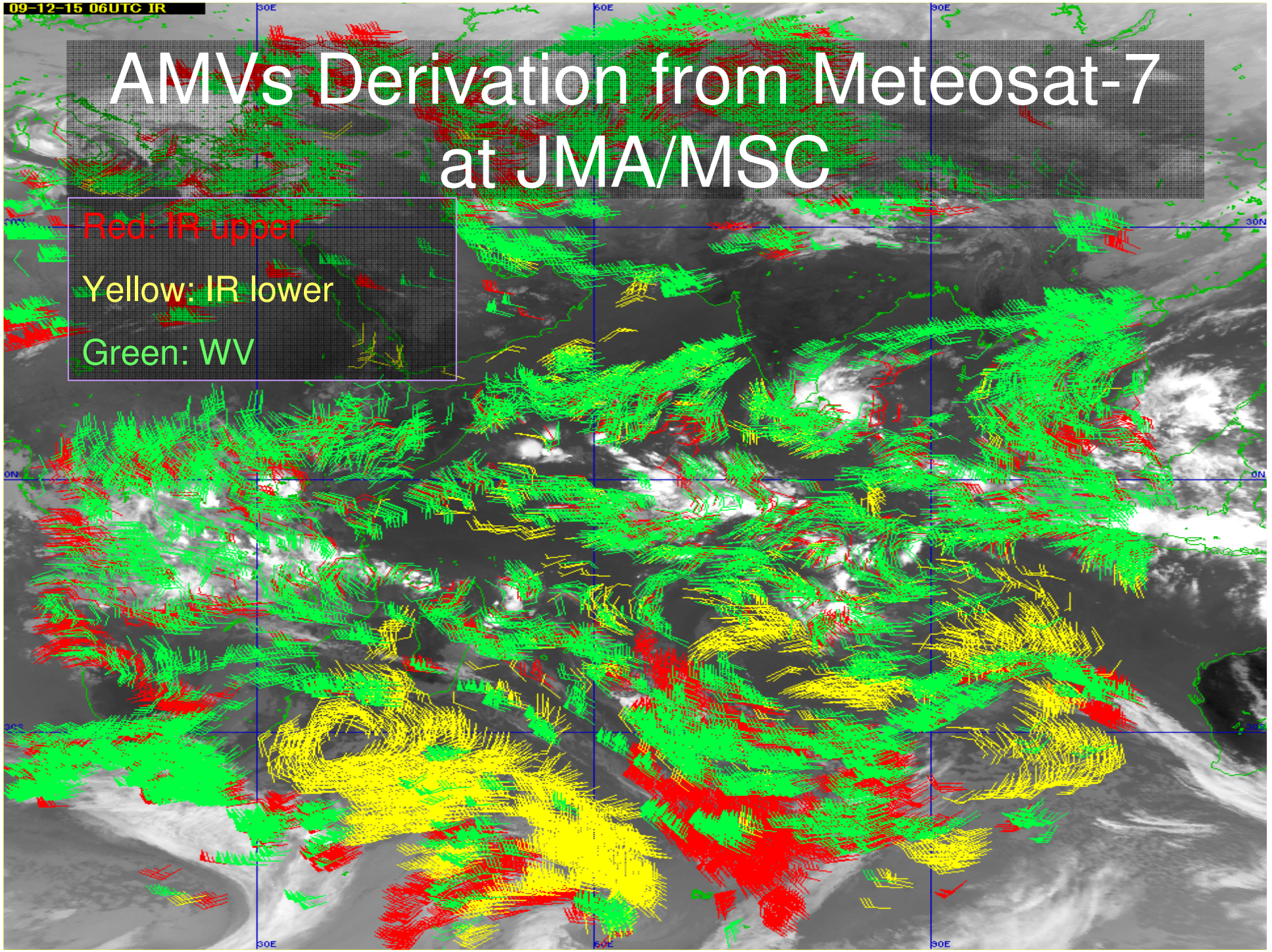
AMV Derivation from Meteosat-7 at JMA/MSC

- Purpose

1. Improvement for frequency of AMVs for JMA NWP
2. By using JMA NWP vertical profile for height assignment on Indian ocean region , It is expected that height assignment dependency on NWP will be clear.

- Future Plan

1. Experiment to NWP model is planned on 2010 after comparison of AMVs dataset and sonde dataset.


09-12-15 06UTC IR
AMVs Derivation from Meteosat-7 at JMA/MSC
Red: IR upper
Yellow: IR lower
Green: WV