The impact of window size on AMV

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Abstract

Target size determination is subjective not only for tracking the vector but also AMV results. Smaller target size may represent more effectively on local wind which contains single layer cloud than multi-layer one. This study will show the estimated AMV from a various target sizes and compared current target size when QI of AMV is greater than 0.6.

Comparison results show that smaller target size has stronger wind speed with bias and Root Mean Square of Vector Difference (RMSVD) of about 0.2 m/s and 1.5 m/s, respectively against current target size. And local wind from target size 8x8 pixels different from mean flow from target size 32x32 pixels exist even though only local wind similar to mean flow is used for comparison due to application of strict threshold of QI in this study. Validation results with rawinsonde observations show that smaller target size decreases bias and RMSVD and height error. This study tells us that target size 16x16 pixels has the best accuracy of all of target sizes in testing.

Objectives

The operational Atmospheric Motion Vector (AMV) determination at Korea Meteorological Administration (KMA) has used cross-correlation method with target size of 32x32 pixels (larger than 160 kmx160 km). Current target which contains broad cloud with multi-layer atmospheric motion system may influence on the magnitude of vector as well as the height of AMV. Thus, determination of target size is very important on AMV estimation.

The purpose of this study is to check the impact of target size on the AMV extraction. AMV information (speed, direction and height) derived from several target box sizes is compared with those of current target size (32x32 pixels). This paper is composed three main studies. First study is to compare AMV from various target sizes against current size. Second study is to compare mean flow from target size 32x32 pixels against average local flows and/or local wind with maximum Quality Indicator (QI) from target size 8x8 pixels. Third study is to validate AMV from different target size with rawinsonde observation.

AMV estimation

We assume that AMV was estimated from cross correlation surface calculated with target area and search area between two satellite images at successive times. Height of AMV was assigned by only Equivalent Black Body Temperature (EBBT) method which uses information of 15% of the coldest pixels within target area. Height of AMV for semitransparent cloud was not corrected in this study.

Finally, QI of AMV was given with range from 0 to 1 by several consistency tests without NWP comparison.

Dataset

Both first and second study used AMV from three consecutive infrared SEVIRI satellite images on MSG at 1212, 1227 and 1242UTC on 18, August 2006 with 15 minute interval time. AMV heights are calculated using middle scene of 1227 UTC data. ECMWF 6 hour forecast data were used to assign AMV heights. Yet the third study used AMV from MTSAT-1R IR channel data with interval time of 30 minutes for a period from 15 June to 31 July 2007 and used rawinsonde observation of 0000 and 1200 UTC for the same period to validate AMV. KMA NWP 6 hour forecast were used for AMV height assignment. All three studies utilized AMV with QI greater than 0.6.

First study

In this study, we checked the impact of target size on wind speed of AMV. AMV were estimated from different target size at same location as shown in figure 1. It is compared against those of current target size. Target size that we used are 8x8, 16x16, 24x24, 32x32, 40x40 and 48x48 pixels. The results are showing that raw AMV information is very noisy for the smallest target sizes which is 8x8 pixels. Smaller target size has worse QI against current target size 32x32 pixels. The larger target size has better consistency of a pair of vectors from three consecutive satellite data.

We add the new filter to inspect the impact of target size on AMV. AMV with height difference less than 50 hPa were compared assuming that they extract from similar feature (50 hPa filter). After we applied 50hPa filter, we lost most of AMV which detected at small scales. Similar impact appears for all of the target sizes. We found out the 50 hPa filter does not improve the general agreement in speed and direction. It just reduced the number of AMV.

Although the limited AMV due to the strict filtering were used, smaller target size shows the tendency that it extracted stronger wind speed against current target size, 32x32 pixels.

Figure 3 shows bias and RMSVD of wind speed for wind speed (left) and height (right) of current target size, 32x32 pixels. Overall, target size did not influence significantly on the magnitude of AMV. However, smaller target size has positive bias than current target size, while larger target size has negative bias than current target size. That means smaller target size sensitive on strong wind speed.

The results tell us that it is true that target size impact on AMV estimation even though it is not large, due to strict filter application in this study.
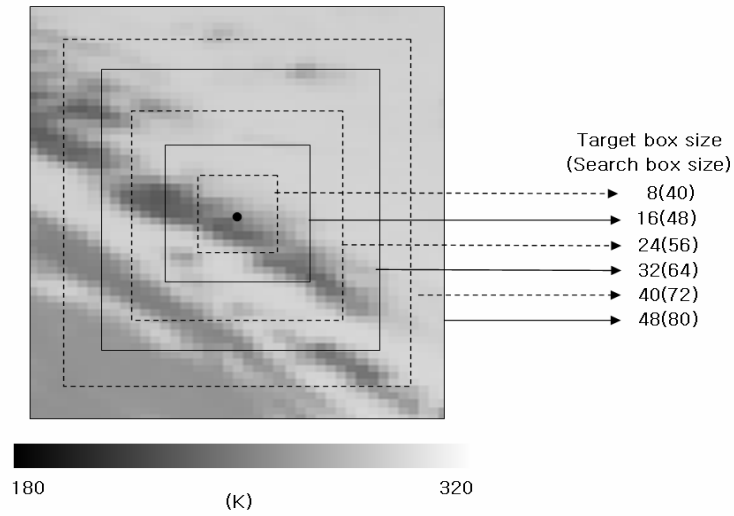
Figure 1. Determination of target sizes for 1st study, target sizes are set in 8x8, 16x16, 24x24, 32x32, 40x40 and 80x80 pixels at the same location.
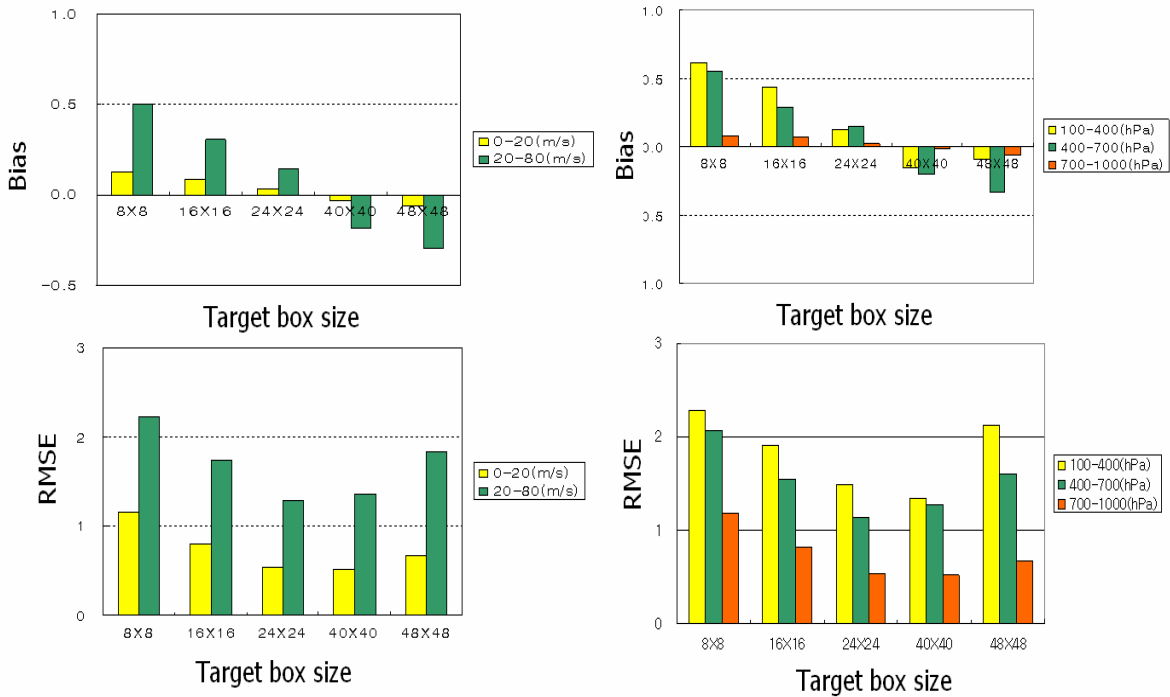

Figure 2. bias and RMSVD of wind speed for wind speed (left) and height (right) derived from current target size, 32x32 pixels.

Second study

In this study, we compared local wind with mean flow. As shown in Figure 3, mean flow was derived from target, 32x32 pixels and several local winds was extracted from 16 target, 8x8 pixels within target 32x32 pixels. Average of local winds with and without QI maximum within 32x32 pixels were calculated and selected, respectively for comparison with against mean flow.

Figure 4 shows the scatter plots of wind speed and direction between mean flow and local wind after contrast and QI filter applied. Without any filtering, 8x8 wind speeds and directions are very different to 32x32 ones, both for average and 8x8 QI max results, especially, when wind speed is less than 20 m/s. After QI filter, mean flow has good agreement with local wind. However, some 8x8 AMV (average and /or QI maximum) passed the QI tests and are different to corresponding 32x32 AMV. Local wind with QI maximum has relatively better agreement with mean flow than average of local wind in wind speed and direction. Most of local winds after QI filter are very close to mean flow as the results of first study. It is because filtering process is very strict for 8x8 local winds, which fails to hunt out different local wind from mean flow. This study is focus to find out dispersion between local wind and mean flow. With this reason it is needed to adjust QI filter.
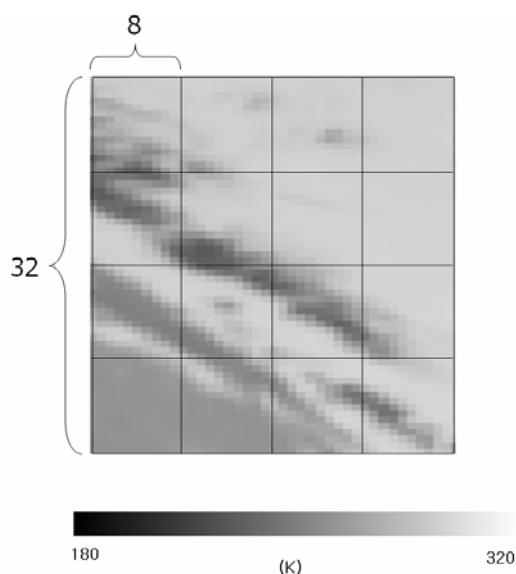

Figure 3. Determination of target sizes for 1st study. Mean flow and local wind are defined by AMV from target size, 32x32 and 8x8 pixels, respectively.
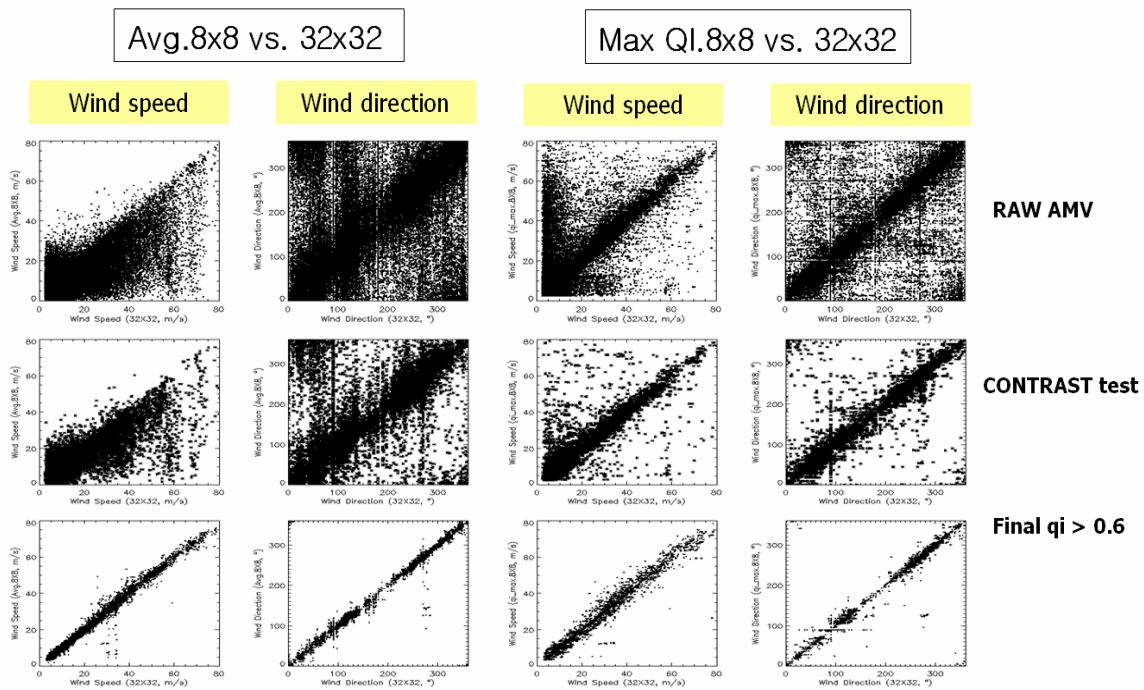
Figure 4. Determination of target sizes for 1st study. Mean flow and local wind are defined by AMV from target size, 32x32 and 8x8 pixels, respectively.

Third study

In this study, we validated AMV from three different target sizes, 8x8, 16x16, and 32x32 pixels using rawinsonde observations. Poor AMV have been eliminated by requiring a quality indicator higher than 0.6 and any collocations with more than differences of 30 ms^{-1} in wind speed and 90° in direction from rawinsonde observations. AMV and rawinsonde observations are collocated only if they are separated less than 150 km in distance, 25 hPa in height, and 1 hour in time.

Figure 5 shows bias (left) and RMSVD (right) for full disk area, tropics and mid-latitude region. Validation results tell us that the 16x16 size targets are more effective in the perspective of wind speed. The wind speed biases of AMV are reduced to -0.8 ms^{-1} with smaller target size (16x16 pixels). Comparing the characteristics of AMV with different target sizes, small target sizes seem to effectively reduce the possibility of containing multi-layer cloud features within the target so that it can be possible to assign the height of vectors more effectively. It appears that it keeps slow satellite-derived winds from being assigned to higher level than expected.

Figure 6 is showing comparison the error of AMV heights from different target size which is defined by the difference of AMV height and level with minimum RMSVD between AMV and rawinsonde observation. We assumes that the vector calculation is perfect and only the height assignment step causes vector errors. Target size of 16x16 pixels was the best performance in terms of accuracy of AMVs and theirs heights, making the smallest RMSVD by dropping the heights of vectors by 86 hPa against 32x32 pixels.
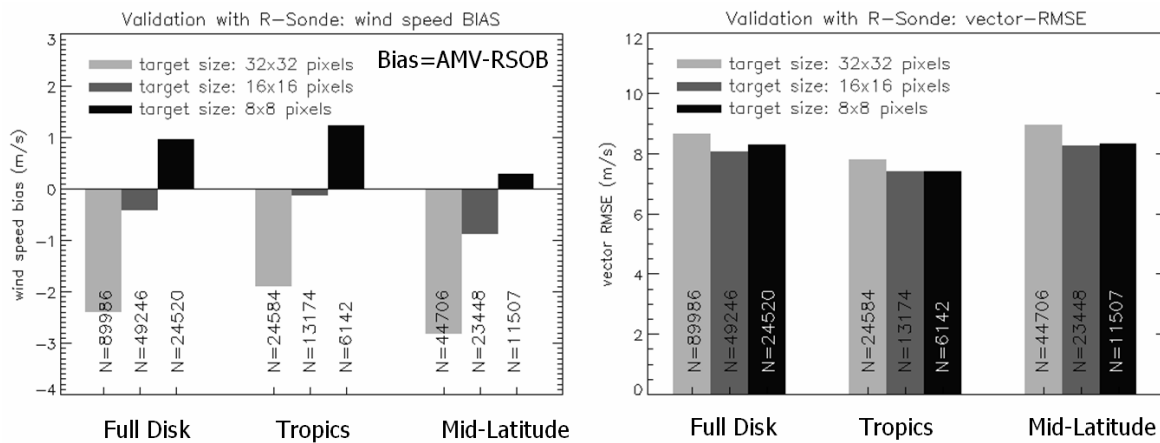
Figure 5. Comparison of accuracies of AMV from different three target sizes, 8x8, 16x16, and 32x32.
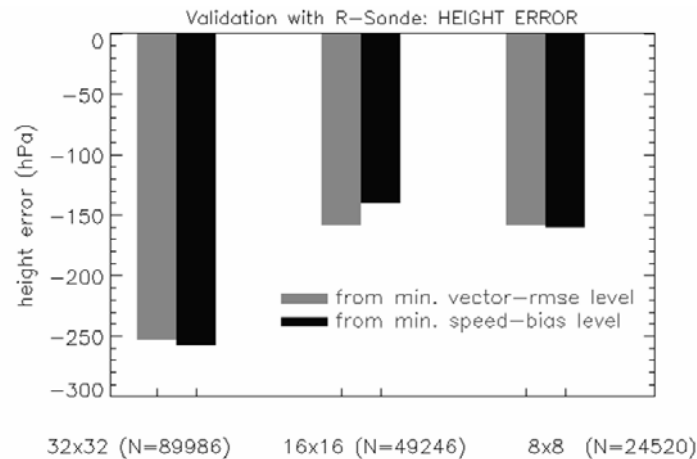

Figure 6. Same as Figure 5 but accuracy for height.

Prospective

The preliminary results of first and second studies showed the fact that target size has an impact on wind speed and direction in vector tracking in spite of relatively strict QI filtering for smaller target size and the removal of different local winds. Also third study told that target size determines the information for AMV height and has influence on the accuracy of AMV. We should understand the dispersion between local wind (8x8 AMV) and mean flow (32x32 AMV) as well as compare the characteristics of AMV from different target size, as mentioned in second study. In the future, we are going to produce different local winds from mean flow using decreased QI threshold for good vectors from smaller target size. And then we will overtake second study to compare and validate the results with ECMWF 6 hour forecasts and rawinsonde observation. Local wind from smaller target size may need to use NWP data with higher spatial resolution than current one with 1x1 degree.