UNCERTAINTIES IN AMV ESTIMATION

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ABSTRACT: Korea Meteorological Administration (KMA) has operationally produced Atmospheric Motion Vector (AMV) from the consecutive MTSAT-1R satellite image dataset. Comparing with radiosonde data, our current AMV scheme shows more than 10 m/s RMSE. Therefore we need to improve continuously its accuracy. Many AMV producers have stated that the bad performance of the Height Assignment (HA) algorithm is the main reason of degrading the accuracy of AMV. The uncertainties in AMV HA can occur in the algorithm itself, used NWP profiles, and the performance of Radiative Transfer Model (RTM) etc. This study introduces currently operated AMV HA schemes and the impacts of NWP profile data and RTM that these schemes use were investigated. Finally we analyzed the relationship between vectors by vector tracking and heights assigned to each vector by using collocated wind profile dataset with radiosonde data. This study is a preliminary work to improve the accuracy of AMV by removing or decreasing the uncertainties in AMV estimation.

KEY WORDS AMV height, RTM, NWP profiles, radiosonde

1. INSTRUCTION

Satellite derived AMV has been regarded as the important meteorological variable in NWP data assimilation and the accuracy of AMV has been improved constantly for several decade years.

Current issue in current AMV is to evaluate the uncertainties in already developed AMV schemes, especially, in a part of HA which has been known as the main cause to drop the accuracy of AMV.

There can be many uncertain factors in AMV HA and it is very complicated and also linked each other. Daniels (2006) stated at the 8th International Wind Workshop that these errors result from utilized HA algorithms themselves or how they are implemented, that is to say, which can contain NWP model error and RTM modelling errors in procedure of AMV HA.

Doutriaux-Boucher also analyzed the MSG wind height assignment problems by comparing with other satellite Cloud Top Pressure (CTP) data. The result showed that MSG high level vector height is retrieved by the CO2 method, while low level cloud is retrieved by the EBBT method and middle level vector is almost not ,comparing with MODIS CTP data.

Besides such uncertainties related with HA schemes, themselves, the relationship of the magnitude of vector by target tracking and height of vector is also still ambiguous. Current HA selects pixels of the lower cloud temperature within target box while target tracking is made by all pixels within target box.

This study is to find the hidden impact of used RTM and NWP data on AMV HA and inspect the feasibilities to improve the accuracy of AMV by comparing with collocated radiosonde wind data.

2. ANALYSIS

2.1 *Impact of the used RTM on AMV height*

AMV HA uses the calculated layer to top brightness temperature of each channel at given levels using RTM.

In order to evaluate the impact of the used RTM on AMV height, SYNSATRAD and RTTOV models were adopted, which calculate radiance for five SEVIRI infrared channels. SYNSATRAD calculates radiance based on the radiance sampling method which is convolved with the spectral response function for each channel of satellite, whereas RTTOV is constructed to contain this convolution implicitly within their transmittance function (i.e. their transmittance functions are channel and satellite specific).

Besides SYNSATRAD can use the user supplied pressure levels while RTTOV uses the fixed 43 pressure levels (1013.5 to 0.1 hPa). Namely, even through the same atmospheric profile for two models is used, for RTTOV modelling, atmospheric profile should be interpolated at the fixed 43 pressure levels specified by RT levels specified by RTTOV. It means that two models apply different atmospheric profiles to calculate radiances.

2. 2. 1 Data:

MSG1 SEVIRI data at 06UTC, Sept. 30, 2005 were used for AMV heights and HA schemes of EUMETSAT were applied. Estimated heights from two different RTM models, SYNSATRAD and RTTOV were compared.

2. 2. 2 Results:

Fig. 1 shows the relative difference of simulated brightness temperature from SYNSATRAD and RTTOV. The difference of calculated radiance between two models, SYNSATRAND and RTTOV was dependent on the spectral characteristics of each channel. Especially, the differences of calculated radiances for window channels between two models were smaller than those for absorption channels. For window channels, IR10.8 and IR12.0 relative difference was of order of 1%, for CO2 channel, IR13.4, 2% and for water vapor channels, IR6.2 and IR7.3, about 5%.

Overall, heights between two models show high correlation greater than 0.9. However, bias and RMSD of height between two models was significantly different from scheme to scheme (Fig. 2). EBBT method made best match with bias and RMSD of 1.2 hPa and 4.5 hPa, respectively. Both of STC and H20 method had larger bias than the other methods with range from 1.5 to 5 hPa. Meanwhile, CO2 slicing methods of all methods are the most sensitive to the usage of two different calculated radiances and had larger RMSD of about 65 hPa than the other methods.

2.2 *Impact of the used NWP on AMV height*

2. 2. 1 Data

Three consecutive infrared SEVIRI satellite data on MSG at 1212 UTC, 1227 UTC and 1242 UTC, Aug. 18 2006 were used to estimate AMV. And AMV heights are calculated on satellite data of 1227UTC.

KMA NWP and ECMWF 6 hour forecast profiles were used as input data of RTTOV8 to calculate the layer to top brightness temperature. Finally MODIS CTP data of 6 granules from 1205 to 1235 UTC, Aug. 18. 2006 were adopted to compare with AMV height, independent other satellite data.

2. 2. 2 Results:

Fig. 3 shows the number density of the calculated layer to top Brightness Temperatures (BT) of infrared and water vapor channels of MSG simulated by RTTOV8 using ECMWF and KMA NWP profiles. Especially as shown in Fig. 3 (c) and (d), when calculated BT of infrared channel is less than 240K, the ECMWF and KMA NWP has the considerable difference greater than 30K in calculated BT of water vapor channel. It shows that there are differences in water vapor profiles between two models. Most of KMA NWP temperature profiles have the inversion layer with temperature of 230K in the range of 100 to 0 hPa and abnormal moisture in the high level for ECMWF. It leads to raise the peak level of weight function of water vapor channel which is dependent on temperature and the amount of water vapor in atmosphere and affect the brightness temperature of water varpor channel. Such a difference of calculated brightness temperature between two models is also expected to estimate the different heights. Result of HA schemes by two different models is given in Table 1. Overall, most of AMV heights have been assigned through EBBT method regardless of used models. And the chance of final height by H_2O intercept method is about 19% for ECMWF profile, 2 % for KMA profile, respectively.

Fig. 4 shows the histogram of the assigned AMV heights and target temperatures. There are primary peaks around 285 K of target temperature in both models, but those are assigned as different levels, about 800 hPa for ECMWF and 700 hPa for KMA respectively. As well as, the histogram also shows that target temperature and assigned AMV height for two models are also different in high level, especially around the target temperature less than 240 K.

It is because ECMWF has higher chance to succeed in height assignment than KMA due to characteristics of H_2O intercept method, that is, KMA seems to be difficult to make the intersection point between the calculated curve and observed line since most of calculated brightness temperature of water vapor channel is concentrated around 230K. H_2O intercept method has the tendency to have higher height for EBBT method because the corrected CTT is mainly smaller than CTT given by EBBT method. Thus relatively high frequency in high level occurs in ECMWF. Meanwhile, KMA has an abnormal peak around 100 hPa which should be corrected by quality check procedure.

2.3 *Relationship of vector by vector tracking and AMV height by HA*

The inconsistency of pixel data that are used for target tracking and height assignment may also induce errors. Tthe vector difference (VD) profiles between satellite-derived AMVs and rawinsonde observation data were calculated (Fig. 5). It is presumed that if the height of the satellite-derived AMV is well assigned, the level of the minimum VD (MIN_VD) would be coincident with the level of the height of the derived AMV.

2. 3. 1 Data:

AMVs estimated at 00UTC, Sept. 4, 2006 using MTSAT-1R satellite data were collocated with radiosonde data over eastern Asia region.

2. 3. 2 Results:

The results show that the height of MIN_VD had no good agreement with that by the inherent height assignment (HA) scheme, which determined the height of AMV by the representative brightness temperature of the coldest cluster within the target area. It is found that the difference of the two heights varied according to sampling methods of the inherent HA scheme. It also appears that the uncertainties in both target tracking and height assignment may exist in AMV scheme simultaneously.

To minimize the uncertainties in both of the height assignment and the target tracking, an optimal target for vector estimation is determined after contrast and sensitivity test according to target size. Then, VD profiles with rawindsonde data are calculated, and comparison between the various HA sample data set and rawinsonde profiles is performed. Finally, the uncertainties in target tracking and sampling methods of inherent HA are estimated.

3. CONCLUSIONS

AMV height is dependent on the NWP profiles and HA schemes and such facts have an effect on the accuracy of AMV which should be evaluated in future. Especially, jn case that the NWP data for AMV HA and background NWP data for data assimilation are different, the impact of estimated AMV on the performance of NWP data assimilation should be analyzed.

Provided that the height is correct, the accuracy of AMV comparing with radiosonde data is related to the performance of vector tracking. The relationship between AMV height and the magnitude of vector should be evaluated through analysis of characteristics within target box.

References:

D. B. Marie, Mary Forsythe, Roger Saunders, and Peter Francis, MSG wind height assignment problems, Forecasting Research Technical Report No. 469.

Daniels J, Christopher Velden, Wayne Bresky, Kyle Turner, and Yi Song, 2006, Operational satellite wind product processing at NOAA/NESDIS: A STATUS REPORT, the 8th International Wind Workshop, 2006.

Acknowledgements:

This study was supported by "Development of the satellite data processing technique (III)" and "COMS Data Processing System Development"

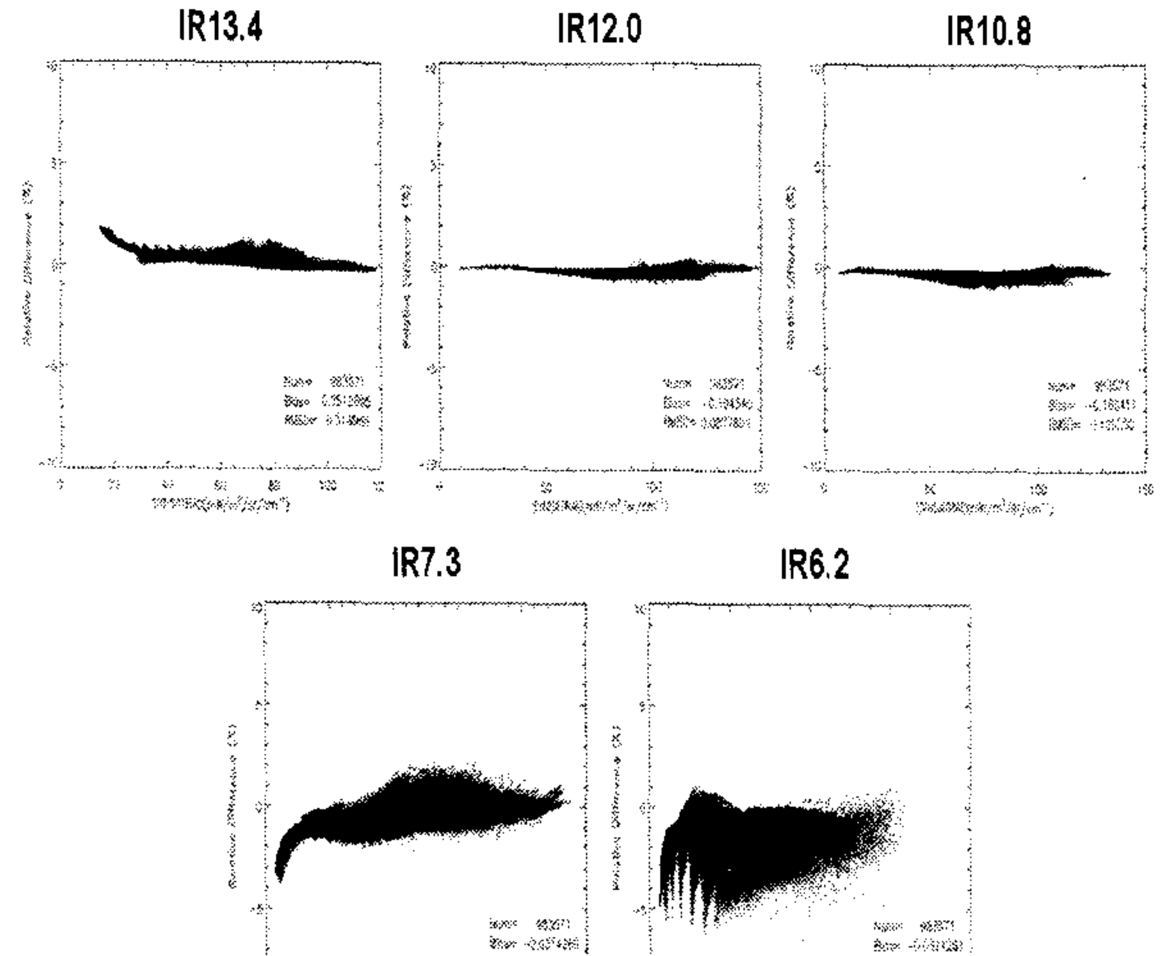

Fig. 1 Relative difference of simulated brightness temperature from SYNSATRAD and RTTOV

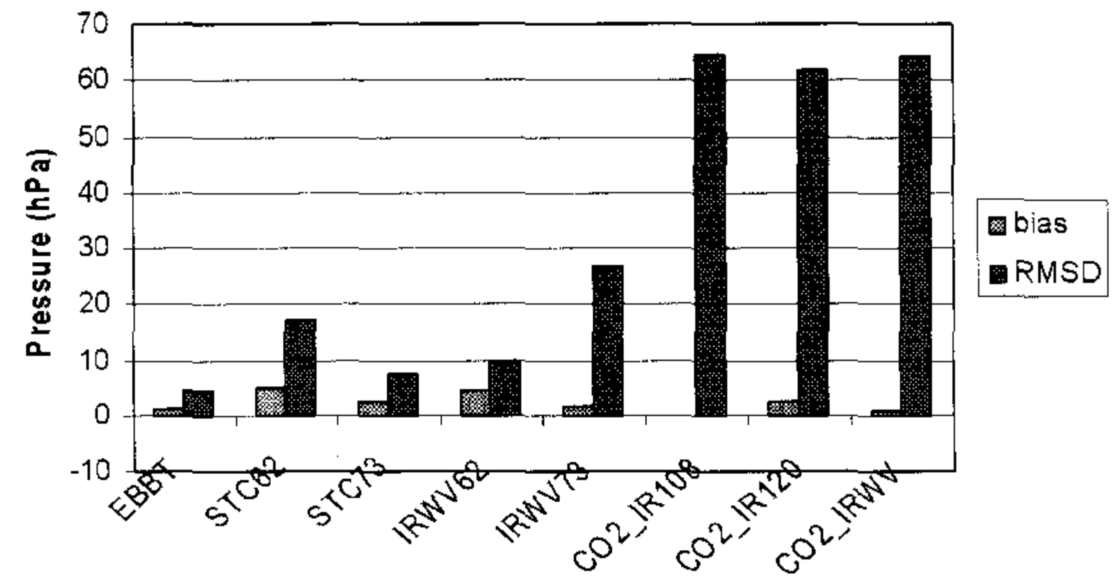

Fig. 2 RMSD and bias of difference of AMV heights assigned from SYNSATRAD and RTTOV.

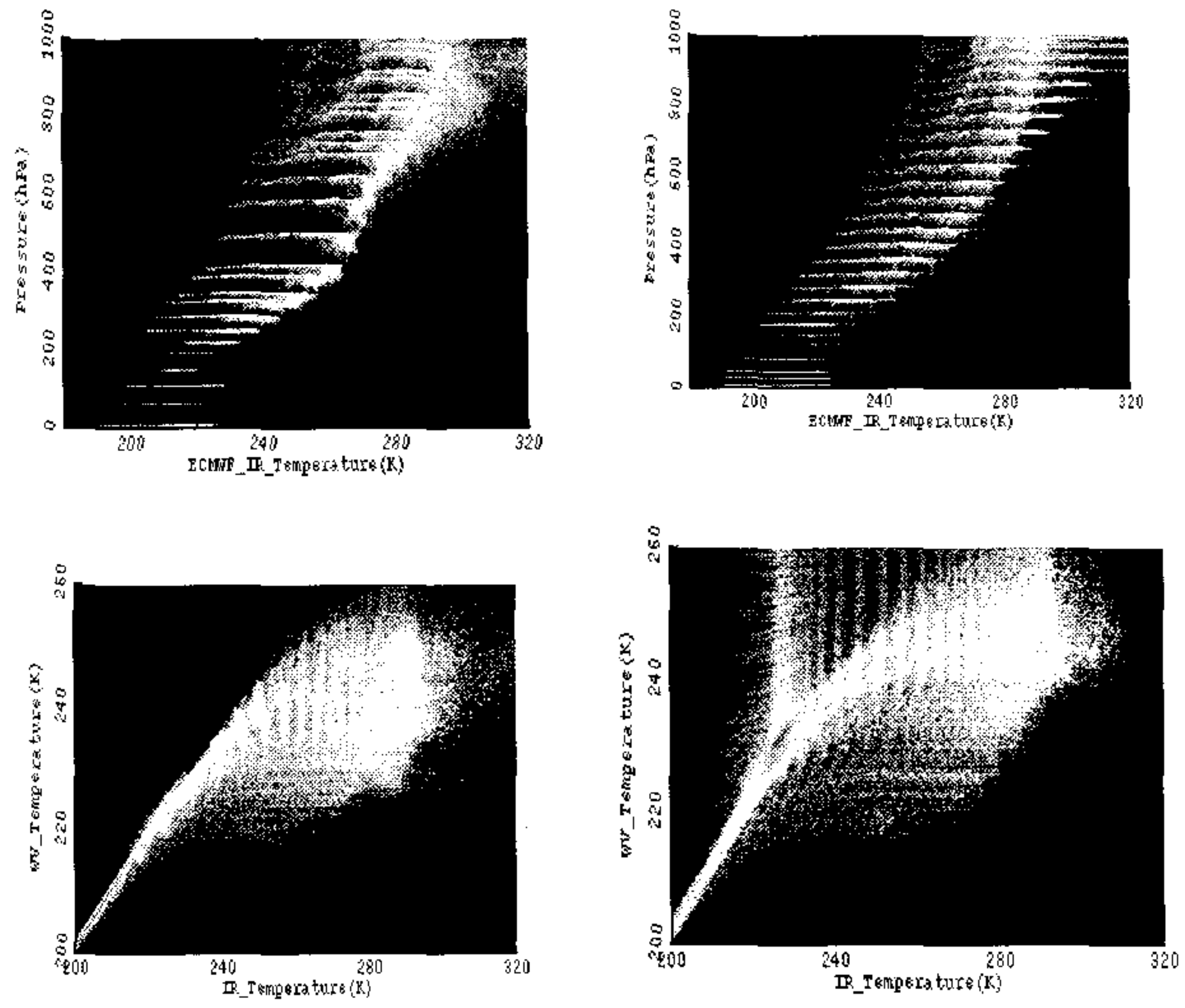

Fig. 3 Distribution of number density of calculated layer to top brightness temperature of infrared and water vapor channel of MSG1 for AMV height assignment.

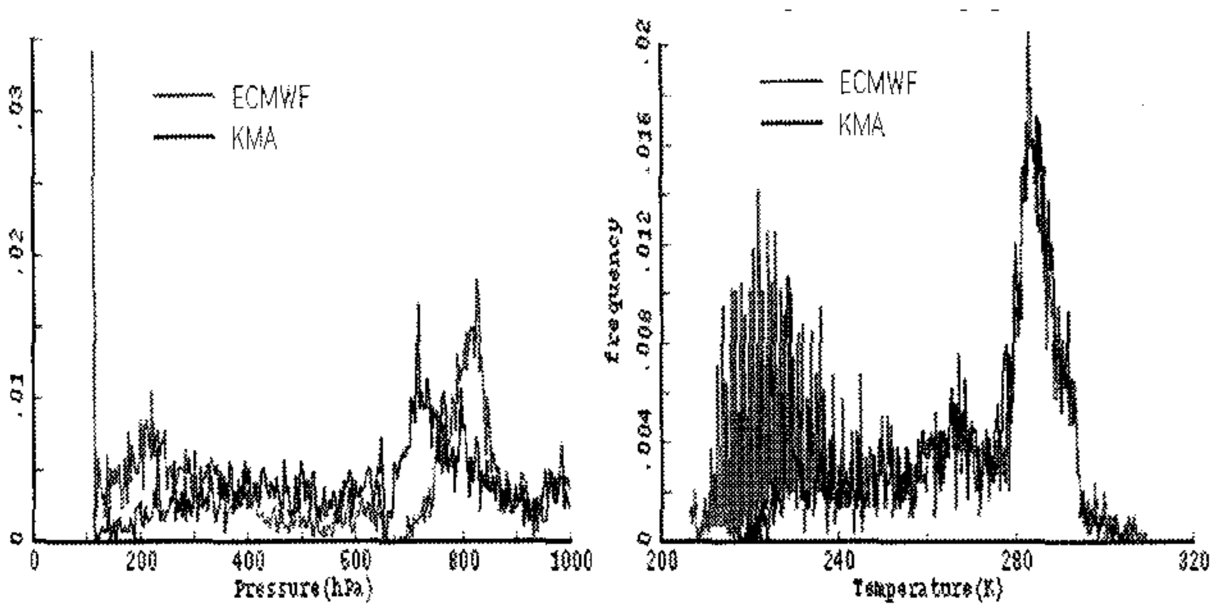

Fig. 4 Histograms of assigned AMV height (left) and target temperature (right), frequency means the percentage.

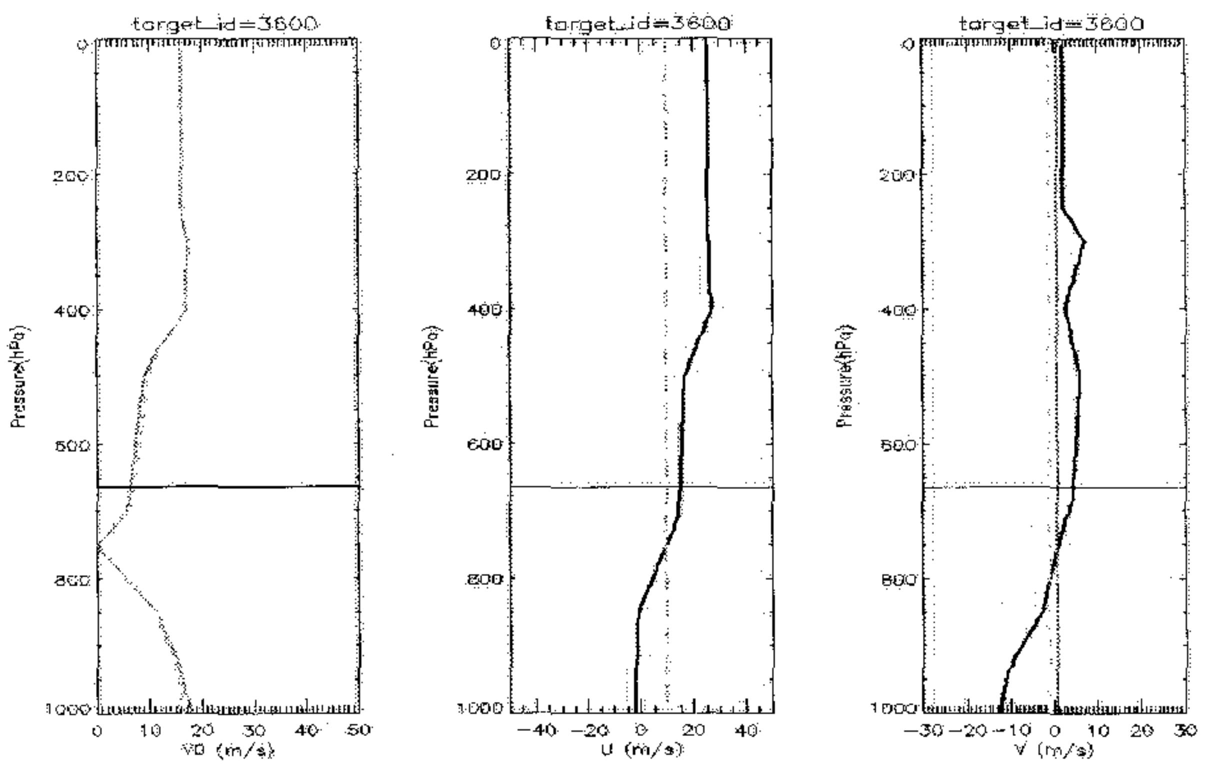

Fig. 5 profile of vector difference between AMV and radionsonde wind profile.