Evaluation of cloud discrimination schemes for MHS brightness temperature assimilation in the KMA numerical weather prediction system

Ji-Eun Cha[1], Dong-Bin Shin[1], Yoonjae Kim[2], Sangwon Joo[2]

Department of Atmospheric Sciences, Yonsei University

Numerical Data Application Division, Korea meteorological administration

Introduction

Microwave sensors (AMSU-A and MHS) onboard Metop satellite have contributed to improvements in NWP skill through data assimilation process. The microwave data (brightness temperature, TB) are sensitive to cloud ice and liquid water. Cloud contamination can thus cause additional biases between the observed TBs and simulated ones from the NWP model first guess. For better use of the microwave satellite data, we have investigated the TB departures for MHS in Korea Meteorological Administration (KMA) NWP system based on the different cloud detection schemes. We also examine a preliminary cloud discrimination skill for MHS data.

Data

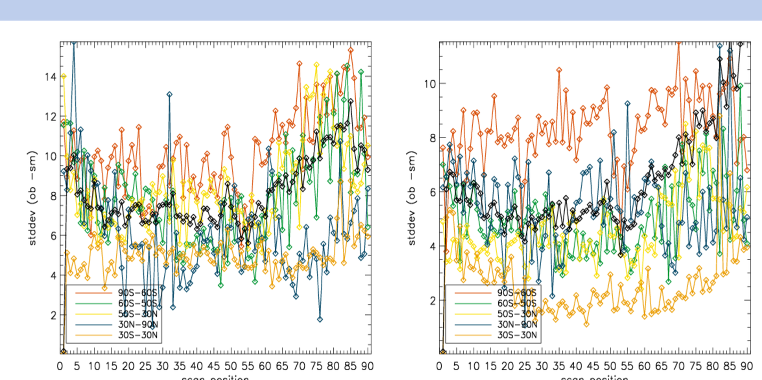
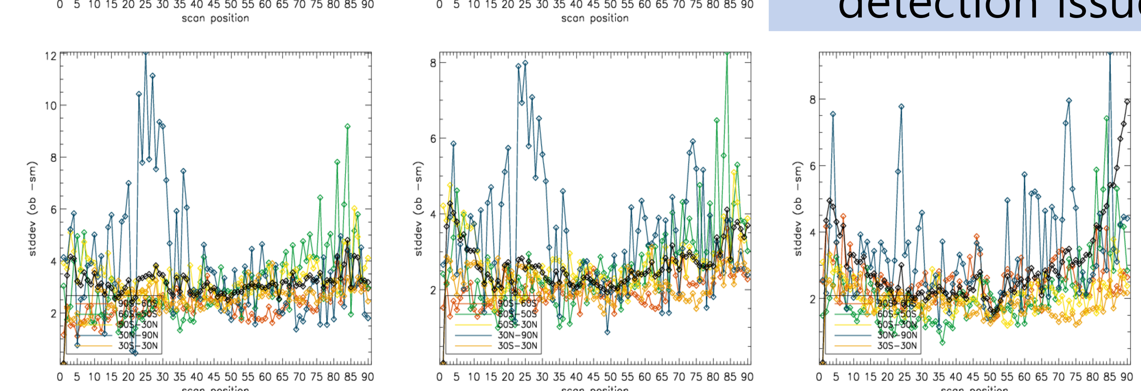
The global UM data from KMA NWP system are used. Every 6 hour forecast data and MHS data were collocated. The satellite data closest to the UM grids were selected for collocation.

NWP model	Global UM (N512) resolution:~25km in mid-latitude (1024 * 769) Vertical levels :70
Satellite	METOP_B
RTM	RTTOV 10.2
period	11-18. 01.2013.

* ticlw: total integrated cloud liquid water(g/m^2)
* ticiw: total integrated cloud ice water (g/m^2)
* O-B : observed TB – Background TB
* OBTB: observed TB
* tsurf: surface temperature

Results

- Scan bias correction

- Scan bias correction for 5 channels of MHS based on Harris and Kelly (2001) for 5 latitude bands has been made.
- The residual bias remain significant in some channels after scan bias correction.
- Biases in high latitudes may be from sea ice detection issues.

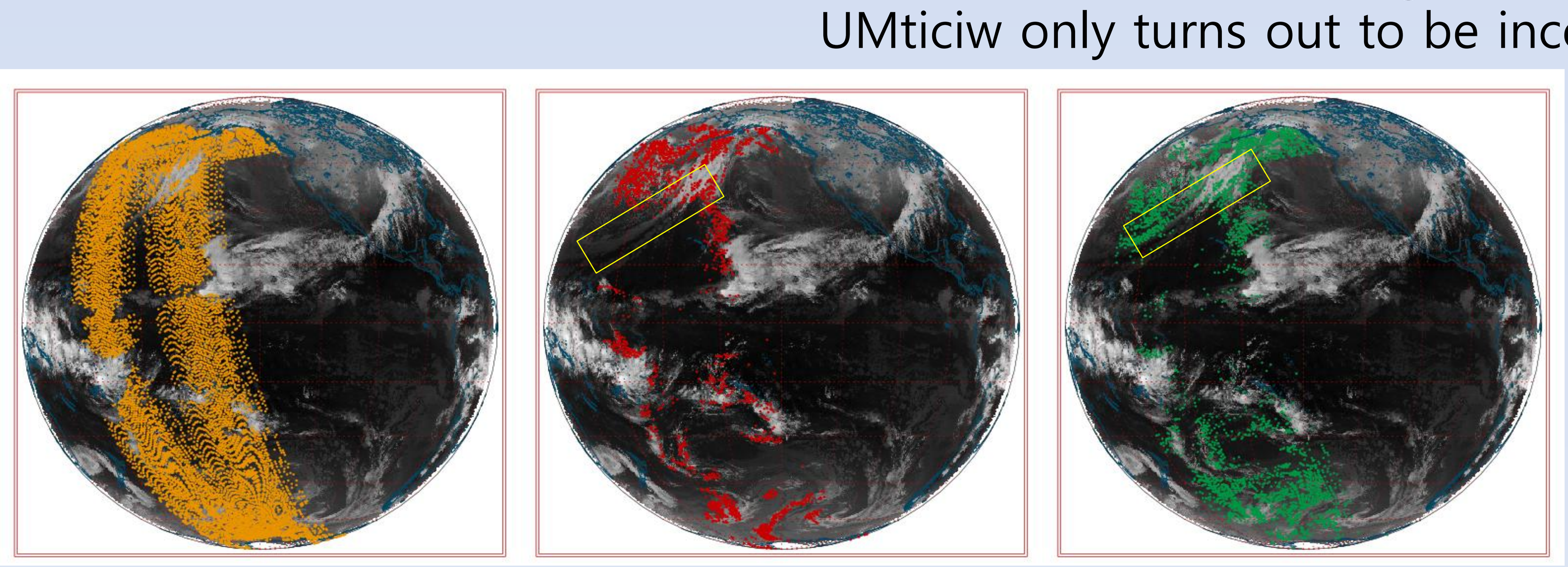
-Correlation with UM ticlw (ticiw)

Variable	TICLW	TICIW
Tsurf	-0.0487	-0.18819
TWV	0.078567	-0.03132
TICIW/(TICLW)	0.298161	0.298161
CH1 OBTB	0.127294	-0.02802
CH2 OBTB	0.069207	-0.13538
CH3 OBTB	-0.02449	-0.22653
CH4 OBTB	-0.03487	-0.28873
CH5 OBTB	-0.01236	-0.27785
CH1 O-B	-0.4109	-0.15786
CH2 O-B	-0.22937	-0.19401
CH3 O-B	0.077259	0.120094
CH4 O-B	0.116344	0.093452
CH5 O-B	0.06824	-0.10169

- There exists significant correlation (0.41) between O-B (CH1) and UM-ticlw.
- Weak correlations between O-B and UM-ticiw for some channels are found.

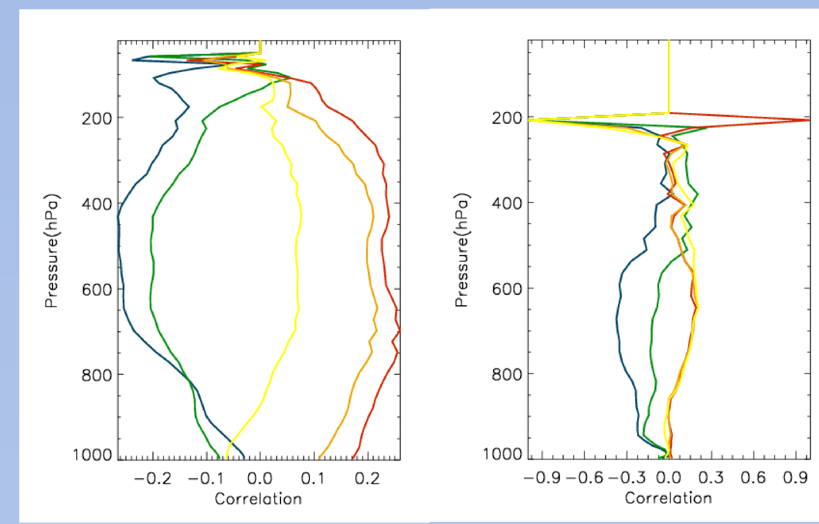
The figures below display collocated rain QC MHS TB (orange) , TB thinned with UM ticiw greater than 50g/m^2 (red) and TB thinned with UM ticlw greater than 50g/m^2 (green).

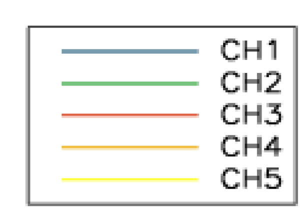
- Red and green dots partially discriminate clouds (yellow boxes show missed clouds).
- Cloud detection through UMticlw or UMticiw only turns out to be incomplete.



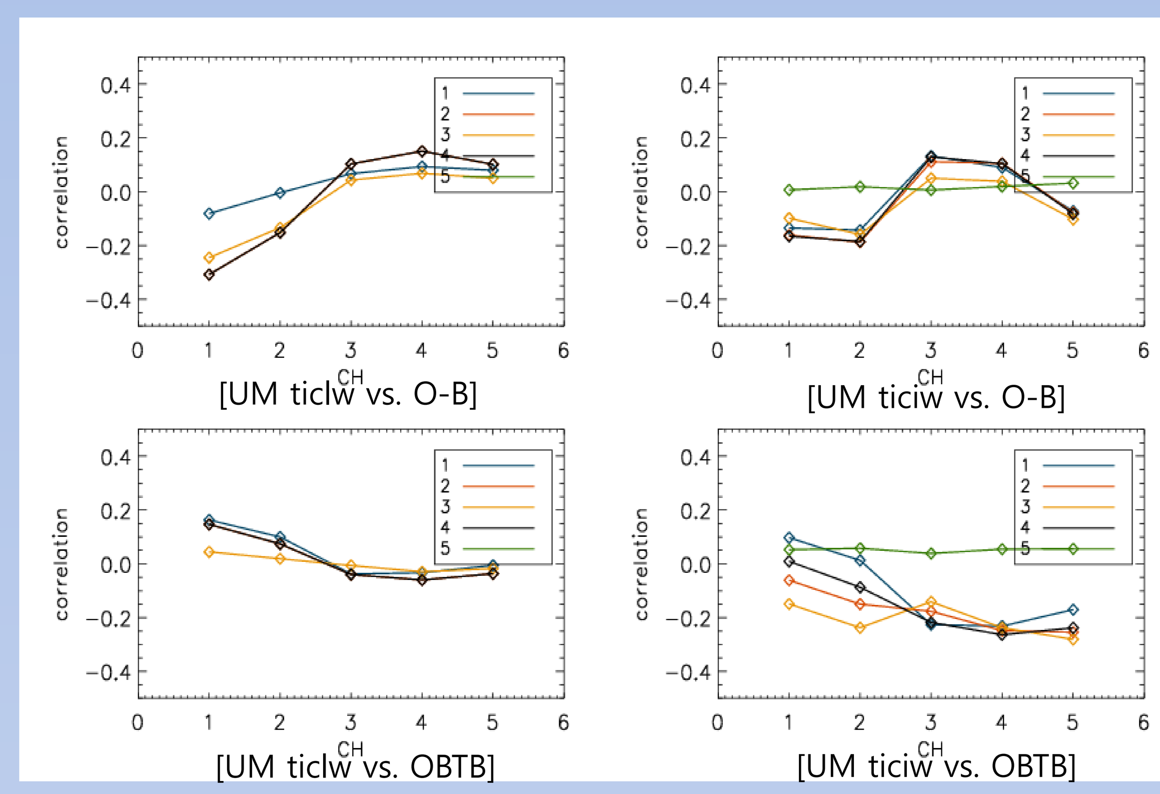
-Correlation of Vertical structure with O-B

We calculated vertical correlation of each channel's O-B with UM ticlw and ticiw profiles. Vertical correlation varies with height. The ticiw correlation with O-B(CH5) is very low and correlation of CH1,CH2 and CH3,4 have opposite sign value. The correlation of ticlw is similar with ticiw. Large correlation at high altitude is due to low distribution.



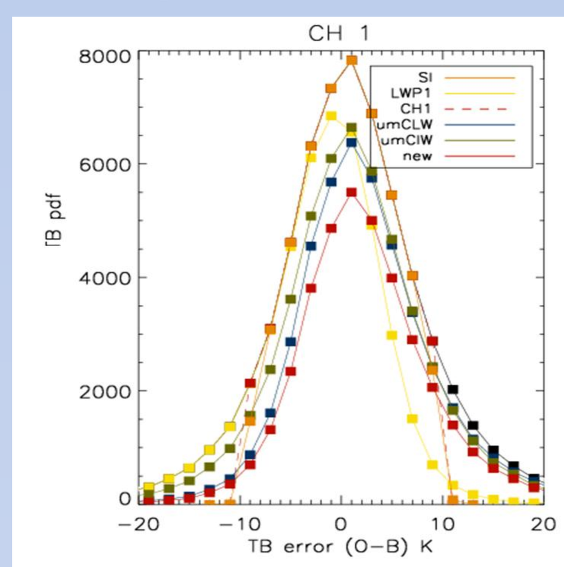


We classified five level cloud structures and observed the correlation between UM ticlw (left column) and UM ticiw (right column) with O-B and OBTB.



number	Column pressure
1	540-150hpa
2	800-400hpa
3	Sfc-800hpa
4	sfc-0hpa
5	70-20hpa

-comparison of cloud discrimination schemes



- Several cloud discrimination schemes are tested for ch1 O-B. We also tested a proposed scheme with combination values of the 800-400hpa columnar integrated UM cloud ice and UM total column cloud liquid water.
- SI algorithm (orange lime) seems to properly reject cloud contaminated data for warm tail region
- The propose method (red line) appears to be appropriate for rejection over cold tail.

❖ LWP1: Xiaolei Zou, Zhengkun Qin, Fuzhong Weng

$$\mathrm{LWP1} = 0.13 \times OminB(ch1) - 33.58 \times \left(\frac{OminB(ch2)}{300 - TB(ch2)}\right)$$

$$LWP1 < 9.$$

❖ SI algorithm: Banghua Yan and Fuzhong Weng and John Derber ,2012

$$dsi = 0.13 \times OminB(ch1) - 33.58 \times \left(\frac{OminB(ch2)}{300 - OminB(ch3)}\right)$$

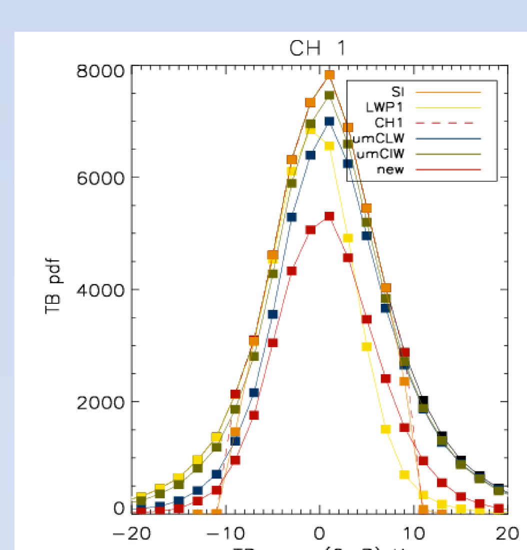
$$factor = (0.1 \times OminB(ch1) - 7.5 \times dsi^2$$

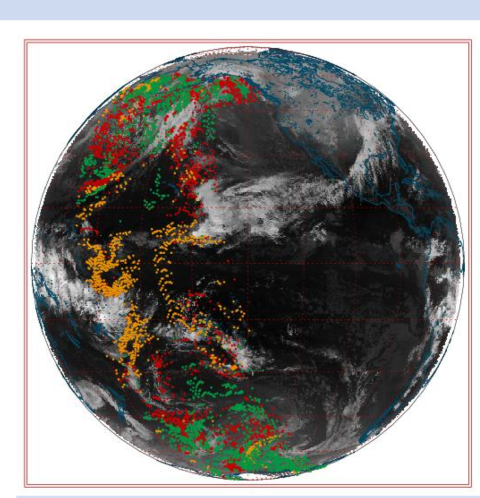
$$factor < 1$$

(-) CH1(O-B)		Correlation
tsurf		0.156057
CH1	O-B OBTB	1.00000 0.169759
CH2	**O-B** OBTB	0.505461 0.152665
CH3	**O-B** OBTB	-0.233764 -0.038115
CH4	**O-B** OBTB	-0.259296 0.0029370
CH5	O-B OBTB	-0.130738 0.0627386

(+) CH1(O-B)		Correlation
tsurf		-0.115204
CH1	O-B OBTB	1.00000 0.161547
CH2	**O-B** OBTB	0.399504 -0.008054
CH3	O-B OBTB	-0.0379952 -0.0665337
CH4	O-B OBTB	-0.0804266 -0.0850765
CH5	O-B OBTB	-0.0868341 -0.0904746

- The characteristics of warm and cold tail is different as you can see from correlation values (left table).
- Regarding cloud contamination from warm tail region, O-B(CH1) greater than 10K is correlated only with O-B(CH2) and OBTB(CH1).





<the result of new scheme>

- Using ticlw>70g/m^2, ticiw> 90g/m^2, abs(O-B(CH2)) > 5K and abs(OBTB(CH1)) > 25K as a new criterion, results have been improved especially at warm tail.
- The right figure shows the final result of new scheme, (red=ticlw+ticiw, green=O-B(CH2), yellow=OBTB(CH1)). Suggesting new scheme properly discriminates clouds.

Conclusion and further work

- The large O-B bias involved in high latitude may be due the uncertainty of sea ice detection algorithm.
- MHS cloud discrimination may consider columnar cloud ice values. Cloud discrimination by using UM ticlw and ticiw are complement each other.
- Consideration of 800hpa-400hpa columnar integrated cloud ice seems to be more effective than total column.
- Characteristics of positive and negative O-B is different, thus we may separately deal with the cloud discrimination.
- We further calculate regression algorithm from O-B information from UM data and check improvements the KMA MHS data assimilation in future.