P1.14 **CALIBRATION OF MTSAT-1R INFRARED CHANNELS USING MODIS/TERRA MEASUREMENTS**

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1. INTRODUCTION

Satellites are useful for not only weather monitoring but also environmental monitoring because many quantitative scientific products. It is imperative that correct calibration should be applied for quantitative satellite measurements. Newly launched Japanese satellite MTSAT-1R (the Multi-functional Transport Satellite-1 Replacement) observes northeast Asia region and it is is essential to the weather forecasting in this region. However, in this purpose accurate calibration is prerequisite. This study uses an intercalibration method, which may provide a monitoring method for the operational calibration and bias correction for global data from different satellites, i.e.: MTSAT-1R IR brightness temperatures are compared with converted values for 3.7, 6.7, 10, 11 μm bands from well-calibrated MODIS (the Moderate Resolution Imaging Spectroradiometer) /Terra measurements.

2. METHOD

There are four steps in this intercalibration method: 1) data collection, 2) spectral response function correction, 3) data collocation, and 4) calculation of mean bias and conversion coefficients.

2.1 *Data collection*

The calibration method is tested for August 2005 and within the 40°N-40°S, 100°E-180°E domain. In order to minimize the navigation error of MTSAT-1R, comparisons are made over the area in which the viewing angle of MTSAT-1R is less than 50°.

MTSAT-1R has one visible channel and four IR channels while MODIS/Terra has 35 channels. For this study, MTSAT-1R 0.2° gridded count values and brightness temperatures for 11 and 12 μm split window channels (IR1 and IR2), 6.7 μm water vapor channel (WV), and 3.7 μm near IR channel (NIR) data and corresponding MODIS/Terra 20, 27, 31, 32 channels data are collected. In addition, MODIS/Terra geolocation product and cloud mask data are collected for data collocation and selection target.

TIGR 2000 data are used as initial atmospheric profile data for radiative transfer model (RTM) simulation from which relationships between MTSAT-1R and MODIS response functions. TIGR 2000 data set, which was used as RTM input data, is a climatological library of 2311 atmosphere profiles. Each atmosphere is described by its temperature, water vapor and ozone profile. RTTOV model, which allows rapid simulations of radiances for satellite infrared or microwave nadir scanning radiometers given an atmospheric profile of temperature, variable gas concentrations, cloud and surface properties, referred to as the status vector (Saunders, 2002) is used for the radiative transfer (RT) calculation.

2.2 *Spectral response function correction*

Since differences in spectral response functions lead to differences in the measured radiance, spectral response function correction is needed. The transfer function converts Terra/MODIS brightness temperature to corresponding MTSAT-1R brightness temperature, but through the RT simulations with a large number of atmosphere profiles (König et al., 1999).

At least for IR window channels, the linear relationship between radiances of similar satellite channels was described by Tjemkes et al. (1997). The model results suggest that the relationship of MODIS/Terra brightness temperature and predicted brightness temperature is described as a linear function for all MTSAT-1R IR channels. Consequently, the transfer function has linear form:

$$TB_{predicted} = a + b \times TB_{MODIS} \quad \ldots (1)$$

where a and b are coefficients calculated from RTTOV simulations. Fig. 1. shows a relationship for the window channel.

Since viewing geometry and surface type also affect radiance, RTM simulations are made for every 5°

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viewing angles and surface type is divided as land and ocean. The slope and the y-intercept of linear function vary with viewing angle difference and surface types. The variation of y-intercept relates to viewing angle is greater than variation of slope. The viewing angle difference has a maximum effect on water vapor channel (0.57 K), because of the water vapor channel is sensitive to the upper tropospheric humidity field between about 200-600 hPa. The effect of surface type difference is smaller than the effect of viewing angle difference.

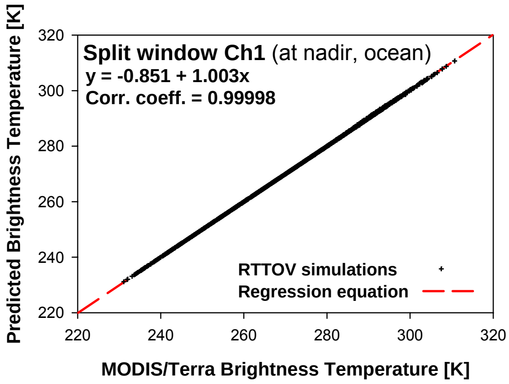

Fig. 1. Scatterplots of RTM simulations for split window channel 1, over ocean at nadir

2.3 *Collocated data construction*

Data collocation requires the consideration of differences of field-of-view (FOV) resolution, viewing angle, and observing time between MTSAT-1R and MODIS/Terra.

First of all, MODIS/Terra brightness temperature pixels of 0.2° resolution grid are averaged for overcoming FOV resolution differences. The maximum viewing angle difference of MTSAT-1R and MODIS/Terra is limited to 5° in order to minimize the effect of atmosphere difference. Gunshor et al. (2004) tested how fast-forward model calculated brightness temperature for the IR window and water vapor regions vary with satellite viewing angle. The brightness temperature difference by viewing angle is less than 0.5 K when the viewing angle and the viewing angle difference are limited 50° and 5°, respectively.

Since surface and atmospheric conditions change with the satellite movement, measured radiances of two satellites are not comparable unless observation time difference is negligibly small. Therefore, MTSAT-1R data are collocated with MODIS/Terra data if the observation time difference is less than 5 minutes.

Near IR channel is also influenced by solar radiation. To remove the effect of solar radiation, collocation data are made only during the nighttime.

Also removed are cloud-contaminated targets because different viewing angle and resolution give difference can result in difference bi-directional reflectances which give rise to different radiances at the TOA. For the cloud MODIS/Terra cloud mask data are used.

2.4 *Calculation of mean bias and conversion coefficients*

MTSAT-1R provides scaled radiances (C) which are related linearly to the radiances L.

$$L = \alpha(C - C_0) \quad \dots (2)$$

where α is conversion coefficient and C_0 is offset count. The goal of this study is to obtain the mean bias and present a new conversion coefficient. In doing so, following equations are used.

$$TB_{predicted} = F(TB_{MODIS}) \quad \dots (3)$$

$$Radiance = \frac{\int B_\lambda(TB) \times \phi d\lambda}{\int \phi d\lambda} \quad \dots (4)$$

$$\alpha_{NEW} = \frac{L}{C - C_0} \quad \dots (5)$$

The radiance obtained from (4) and corresponding MTSAT-1R count are regressed to obtain new conversion coefficient α_{NEW}.

3. RESULT

Fig. 2. compares MTSAT-1R measurements from four channels with comparable MODIS/Terra measurements. The inclusion of homogeneous cloud targets for the calibration is also tested since clear surface target provides relatively warm pixels and thus cold pixels lack when only clear targets are used.

In Fig. 3, the water vapor channel results show scattered brightness temperature distributions in the range of lower than 220 K, while two split window and near IR channel results show distributions similar to those from clear target approach. It is likely due to the fact that the water vapor channel measurement is sensitive to UTH and also sensitive to upper level cloud. In order to remove contamination by upper level clouds, the homogeneous cloud targets were not used in case of water vapor channel.

Table 1 summarizes obtained calibration results. It shows that the current calibration of MTSAT-1R spilt window and water vapor channels are generally in good agreement with MODIS/Terra. On the other hand, the mean bias and RMSE of near IR channel are much lager than other channels. Theses results indicate that data quality of near IR channel is questionable.

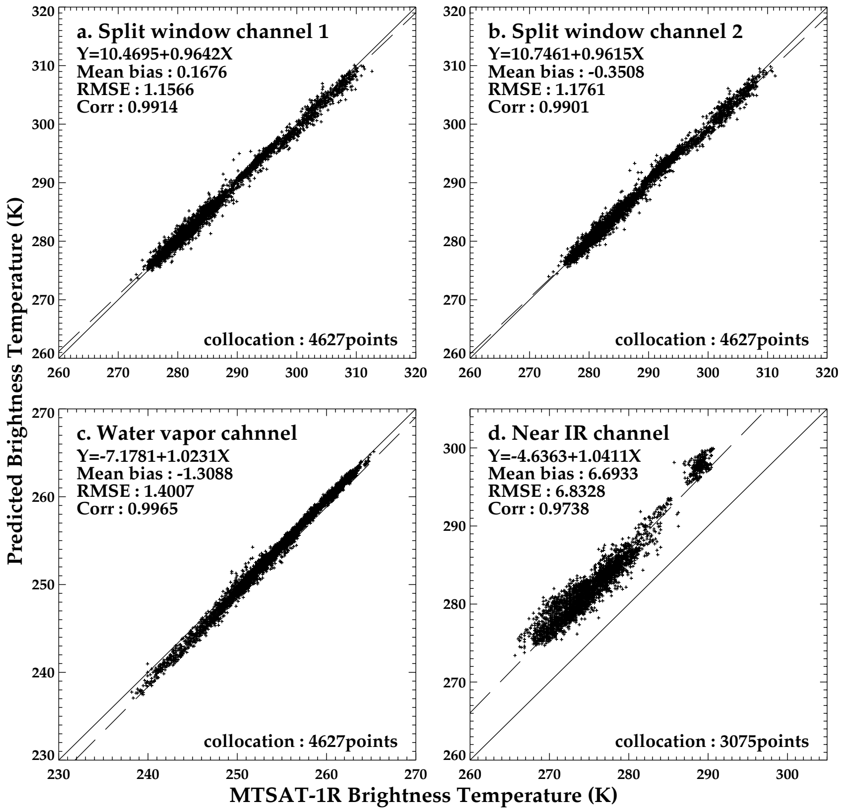

Fig. 2. Scatterplots of predicted and measured MTSAT-1R brightness temperatures in cases of clear target for (a) split window channel 1, (b) split window channel 2, (3) water vapor channel, and (4) near IR channel

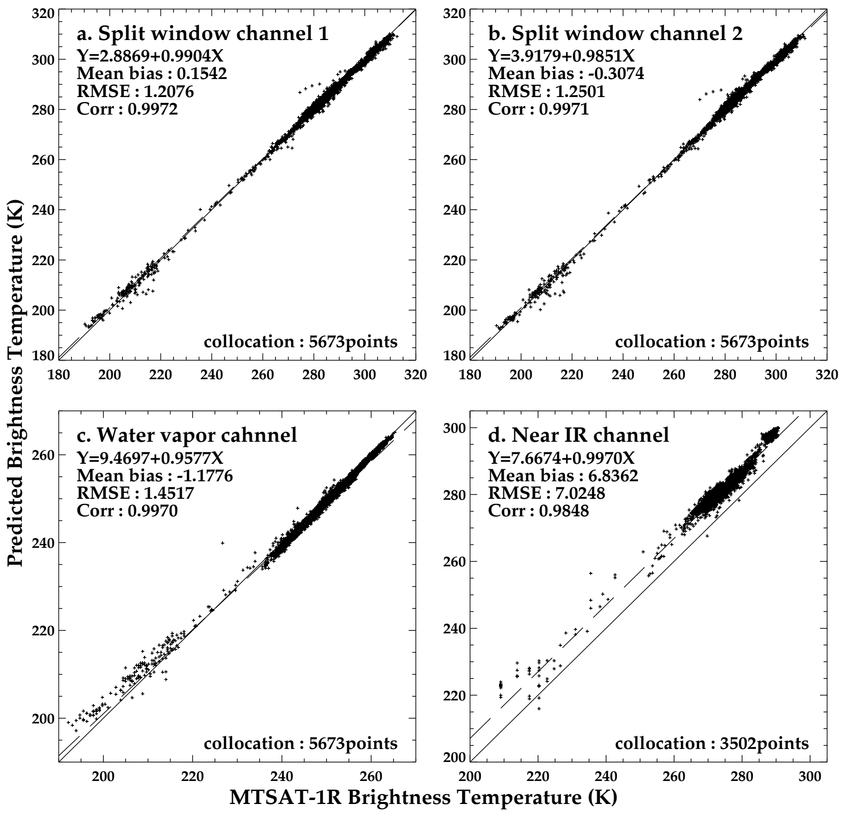

Fig. 3. Scatterplots of predicted and measured MTSAT-1R brightness temperatures in cases of clear and homogeneous cloud target for (a) split window channel 1, (b) split window channel 2, (3) water vapor channel, and (4) near IR channel

Table 1. Mean bias and RMSE of MTSAT-1R IR channel for predicted brightness temperature

	Split window ch 1	Split window ch 2	Water vapor ch	Near IR ch
Mean bias	-0.17	0.35	1.31	-6.70
RMSE	1.16	1.18	1.4	6.8

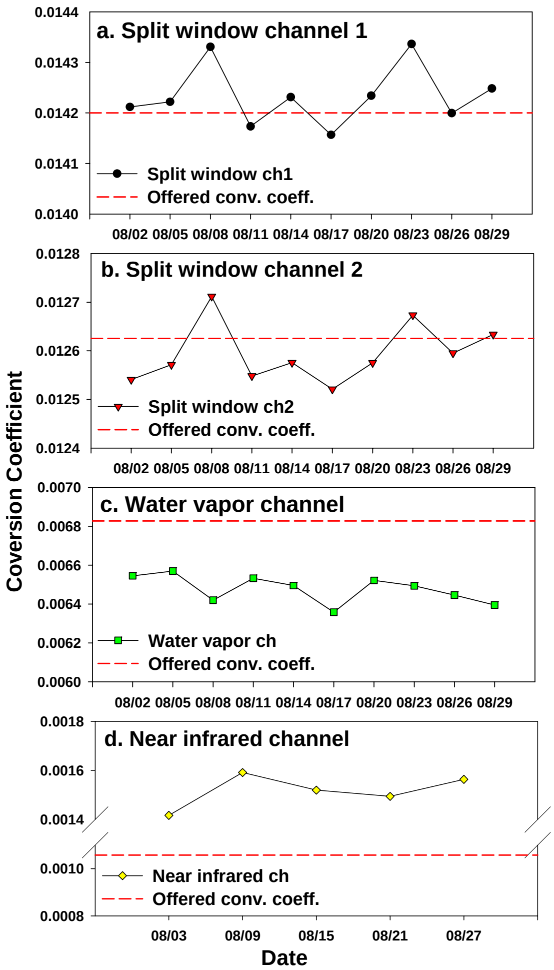

Fig. 4. Time series of conversion coefficient for (a) split window channel 1, (b) split window channel 2, (3) water vapor channel, and (4) near IR channel

Fig. 4. illustrates time series of new conversion coefficient (solid line) and offered conversion coefficient (dashed line). Since daytime data of near IR channel is excluded, new conversion coefficient is calculated at every 6 days for near IR while 3 days for other three channels.

4. CONCLUSIONS

Intercomparison indicated that mean biases of two split window and water vapor channels are about -0.17 K, 0.35 K and 1.31 K, suggesting that accuracies of those three channel measurements are comparable to MODIS measurements. It was suggested that the accuracies of split window channels are better than water vapor channel and the mean bias of water vapor channel about 1 K is consistent with recent result (Gunshor, M. M. et al., 2006). On the other hand, the mean bias of near IR channel shows a much larger difference of up to -7.23 K and RMSE is 5-6 times larger than other channels, indicating that data quality of near IR channel is much questionable. Furthermore, the relationship between near IR channel brightness temperature of MTSAT-1R and of MODIS/Terra appears to be non-linear for the NIR channel.

5. ACKNOWLEDGEMENTS

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