INTERCALIBRATION OF THE MTSAT-1R INFRARED CHANNELS WITH A POLAR ORBIT SATELLITE

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ABSTRACT:

Meteorological imager on the Multi-functional Transport Satellite (MTSAT-1R), which has been operating formally since 28 June 2005, was intercalibrated with a polar orbit satellite [Aqua Moderate Resolution Imaging Spectroradiometer (Aqua/MODIS)] as a well-calibrated instrument. The intercalibration method used in this study was developed by the Cooperative Institute for Meteorological Satellite Studies (CIMSS). This was done for the infrared window channels. The differences of MTSAT-1R and MODIS were are –0.26 K for 11 μm-IR window channel, 0.40 K for 12 μm-IR window channel, and –0.67 K for 6.7 μm-water vapor channel.

KEY WORDS: Intercalibration, MTSAT-1R, MODIS, Infrared Channel

1. INTRODUCTION

The most valuable characteristic of geostationary meteorological satellite is to monitor global atmospheric phenomena continuously. On the other hand, for the extraction of valuable geophysical parameters such as the sea surface temperature, the measured raw data, i.e. radiances, should be well calibrated. Furthermore, for the long-term global and regional environmental monitoring, stable and accurate information are highly required. There are many approaches to insure such high quality, including onboard calibrator and vicarious calibration. Among the many vicarious calibration, comparison between the collocated, in terms of temporally and spatially, data has been widely used. Most of cases, the lesser known data are calibrated against the other which has well known calibration characteristics.

A Japanese satellite, the Multi-functional Transport Satellite (MTSAT-1R) was successfully launched on February 26, 2005. MTSAT-1R replaces the long-served Geostationary Meteorological Satellite (GMS) series as the next generation satellite series covering the East Asia and the Western Pacific regions from 140°E above the equator. After the successful in orbit test, MTSAT-1R began its formal operation from June 28, 2005.

For a better characterization and use of the newly commissioned MTSAT-1R direct broadcasted data, we compare MTSAT-1R data with the well calibrated Moderate Resolution Imaging Spectroradiometer (MODIS) of Aqua satellites.

2. METHOD

Inter-calibration of measured radiances helps to validate the findings of longer-term environmental studies using satellite data. Different characteristics of measured radiances between various operational satellite als can be determined by continual inter-calibration (Gunshor et al. 2004).

For the inter-calibration we firstly collected satellite data and transformed followed by the aerial selection for a better inter-calibration. The collocated data are compared by using several statistical methods.

2.1 Data collection

Collection of the MODIS of the Aqua and Terra as a polar orbit and MTSAT-1R as a geostationary satellite data in space and time is required. With the ground receiving station operated by Korea Meteorological Administration (KMA), we collect the direct broadcasted MODIS data. While MTSAT-1R cover most of Asia and tropics, data coverage by the direct broadcasted MODIS data spans from eastern part of China to the most of Japan, and from Taiwan to eastern part of Russia. Also, MTSAT-1R measure radiances at least every 30 minutes, the MODIS data have temporal resolution of about 12 hours. Thus, collocating the two satellite data requires a careful selection of spatial and temporal window.

We choose temporal window of ±15 minute of MODIS overpass time at the MTSAT-1R point to maximize scene consistency between the two instruments. As the spatial resolution is different, MTSAT-1R being 4 km at nadir while MODIS being 1 km at nadir, we transform the two satellite data explained following subsection.

2.2 Data transformation

We smooth the two satellite data into an effective 100 km resolution to mitigate the effects of different IFOV (Instantaneous Field Of View) sizes and sampling densities. This image smoothing is done using a running average. Each pixel of the resultant image is the average of the approximate 100 km X 100 km surrounding it.

2.3 Selection of the study area

We select an area of between 25~30°N and 130~135°E where most of the obtained MODIS data are available. We also considered the satellite zenith angle. According the radiative transfer model calculation, the brightness temperature for IR and water vapor channels vary by satellite zenith angle from the nadir view. The difference between a nadir view and the satellite zenith angles for the geostationary and polar orbiting satellites is generally be very small (less than 0.1 K) and even at the most extreme angles possible less than approximately 0.3 K in the water vapor channel, where the effect is most pronounced (Gunshor et al. 2004). In this study, because the obtained MODIS data is the overpass data over the Korean Peninsula, we select the study area considering the satellite zenith angle among the overlapped area with the MTSAT-1R.

2.4 Calculations

The mean observed radiance is calculated by averaging the spatially smoothed data within the study area for each instrument. And the radiative model calculated radiance is computed by the Radiative Transfer model for ATOVS (RTTOVS) using the Global Data Assimilation and Prediction System (GDAPS) of Korea Meteorological Administration (KMA) as an input data. The difference in the calculated radiances for the two instruments is used to account for the differences in their spectral response functions. Conversion from radiances to temperatures for a comparison between satellites is accomplished by

$$\Delta T = [B^{-1}{}_{mean} - B^{-1}{}_{cal}]_{Geo} - [B^{-1}{}_{mean} - B^{-1}{}_{cal}]_{Leo} \quad (1)$$

where B^{-1} indicates brightness temperature using the inverse Planck function.

The comparison channels of two instruments are shown in the Table 1.

Table 1. Bandwidth of comparison channels of MTSAT-1R and Aqua/MODIS.(NASA 2000; JMA 2005)

Channel ID	MTSAT-1R	Aqua/MODIS
CH1	10.3~11.3 μm (IR1)	10.780~11.280 μm (Band 31)
CH2	11.5~12.5 μm (IR2)	11.770~12.270 μm (Band 32)
CH3	6.5~7.0 μm (Water Vapor)	6.535~6.895 μm (Band 27)

3. RESULTS

The inter-calibration case is the time of 0400 UTC on 23 July 2005 for MTSAT-1R and 0404 UTC for Aqua/MODIS. The study area is the range of between 26~30°N and 131~133°E.

Figure 1 is shown the study area images of MTSAT-1R IR1 and MODIS Band31. The pixel values for each instrument were smoothed to a 100 km resolution and then computes an average of the study area. In this Figure, the mean brightness temperature was 295.43 K for MTSAT-1R and 295.59 K for MODIS (see Table 2).

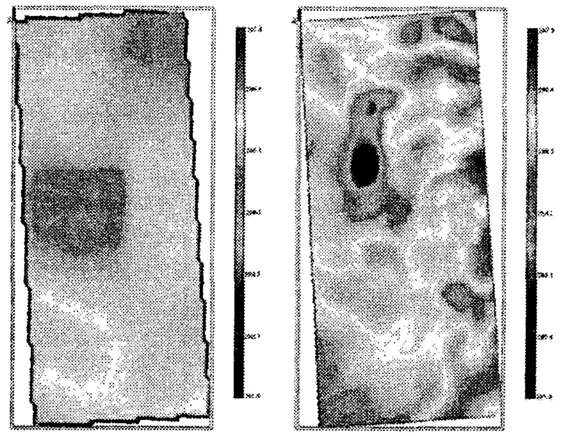

Figure 1. CH1 Images from MTSAT-1R (left) and Aqua/MODIS (right) from 23 July 2005.

Table 2. The observed and calculated brightness temperatures.

Channel ID		MTSAT-1R	Aqua/MODIS
CH1	Observed	295.43 K	295.59 K
	Calculated	296.86 K	296.76 K
CH2	Observed	294.20 K	294.22 K
	Calculated	295.27 K	295.69 K
CH3	Observed	249.87 K	251.03 K
	Calculated	253.22 K	253.71 K

Figure 2 shows the scatter plot of Figure 1 images. Because the brightness temperature of MTSAT-1R is not expressed the extreme value which is shown in the Aqua/MODIS image, the correlation coefficient is not so high (R=0.23 for CH1).

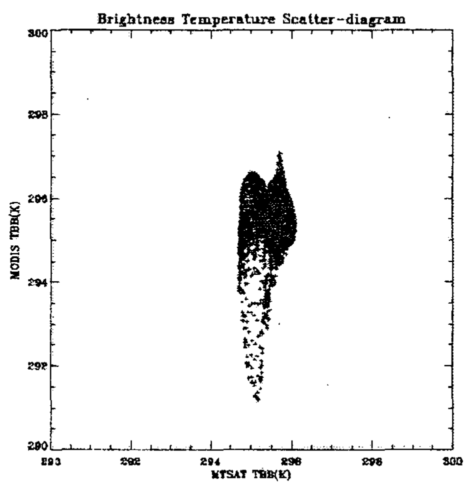

Figure 2. Scatter plot of CH1 images.

The brightness temperature differences (ΔT) of CH1, CH2 and CH3 are –0.26 K, 0.40 K and –0.67 K, respectively. The negative sign indicates that the MODIS measurement is warmer than MTAT-1R measurement. This result is not considered about the bandwidth of each channel of two instruments and the values from the area which has a relatively large satellite zenith angle (30~40°). However, the result from this case shows a good agreement between MTSAT-1R and Aqua/MODIS.

4. CONCLUSIONS

The brightness temperature differences of MTSAT-1R and Aqua/MODIS are about 0.3 K for IR window channels and 0.7 K for water vapor channel. However, because this value is calculated from only a case, it is not possible to determine the calibration value of MTSAT-1R IR channels. Therefore, more cases from a long period and comparisons of other satellite instruments (e.g., Aqua/AIRS) for more accurate intercalibration are needed.

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