Reproduction of GMS IR calibration table

Hideyuki Sasaki *
Meteorological Satellite Center

1 Introduction

GMS series satellites have a function to prepare individual IR calibration tables for every images. But before February 1987, an operational calibration table was derived from daily mean calibration data and it was updated once a day. It means that the same table was used for eight images which were taken from 06GMT to the next 03GMT. If any diurnal change or random fluctuation occurs in IR sensor, brightness temperatures derived from daily mean calibration table are unsuitable, because such change or fluctuation are directly reflected on IR count levels.

The followings are the results of the reproduction of IR calibration tables for all images from July 1983 through February 1987. During the period, an operational satellite was GMS-2 from January 1983 to January 1984 and from July to September in 1984, GMS from January to June in 1984 and GMS-3 from September 1984 up to now.

2 Reproduction procedure

The calibration of IR sensor is expressed by the following equations.

$$C = \beta_0 + \beta_1 \cdot V \qquad V = \alpha_0 \cdot E + V_0 \qquad (1)$$

Where C, V and E are IR count level, out put voltage and radiance respectively. The coefficients β_0 and β_1, which express the linear relationship between IR count level and an output voltage, are determined by staircase calibration procedure. The coefficients α_0 and V_0, which express the linear relationship between an output voltage and radiation, are determined by shutter calibration procedure. These coefficients, daily mean β_0, β_1, and three hourly α_0, V_0, have been stored as a compact data set since September 1982.

For the images whose calibration data are not archived, the calibration coefficients are inferred by two methods, (1) based on the coefficients at the same observation time before and after the day, and (2) based on the coefficients before and after the observation time on the same day. The first method is applied to most images by using a linear interpolation. The second method is applied to the images at 16Z before August 25 1985 because of no calibration data at 16Z during the period.

The second method uses the following relation:

$$A = \frac{X_{16} - X_{12}}{X_{18} - X_{12}} \qquad B = \frac{X_{18} - X_{21}}{X_{18} - X_{12}} \qquad (2)$$

where X is a calibration coefficient (β_0, β_1, α_0, V_0) and a subscript shows the observation time. If the ratio A is known, the calibration coefficients at 16Z are expressed,

$$X_{16} = A \cdot X_{18} + (1 - A) \cdot X_{12} \qquad (3)$$

During none eclipse period, the ratio A is treated as 0.5. That is a simple mean of 12 and 18 Z. On the other hand, during eclipse period, the ratio A is not so simple because of a drastic change of the IR sensor. In this work, the ratio A and B are treated as constants with each spacecraft. They are estimated empirically by averaging daily values during eclipse period. The ratio B is known for all spacecrafts because the calibration coefficients at 12, 18 and 21Z are archived during whole period. But the ratio A is known only for GMS-3

* Meteorological Satellite Center
System Engineering Division

Table. 1 The ratio $A = (X_{16}\text{-}X_{12})/(X_{18}\text{-}X_{12})$ for an estimation of the calibration coefficients at 16Z. The * shows an inferred value from the relation between the ratio A and $B = (X_{18}\text{-}X_{21})/(X_{18}\text{-}X_{12})$ of GMS-3.

Period	Satellite	A	B	A/B
None eclipse (July 1 1983-Aug.25 1985)	GMS GMS-2 GMS-3	0.5	0.5	−
Autumn eclipse (1983)	GMS-2	1.20*	0.55	2.18*
Spring eclipse (1984)	GMS	0.68*	0.31	2.18*
Autumn eclipse (before Sept.27 1984)	GMS-2	No observation at 16Z		
Autumn eclipse (after Sept.27 1984)	GMS-3	1.42	0.65	2.18
Spring eclipse (1985)	GMS-3	1.42	0.65	2.18

(after Aug.26 1985). So, the ratio A of GMS and GMS-2 are inferred by A/B =2.18 of GMS-3. The ratio A and B are summarized in table 1.

Thus, all calibration coefficients are prepared and IR count-radiance conversion table is calculated by using the equations (1). Finally, IR count-brightness temperature conversion table is calculated by using the energy-brightness temperature conversion table which is constant for each satellite.

3 Results and Conclusion

Brightness temperatures equivalent to 160 IR count level are used to evaluate IR calibration because IR count levels near 160 are regarded as typical values over water in a clear condition. An example of current IR calibration table is shown in Fig.1. Brightness temperatures (160 IR count level) are plotted by cross marks whose interval is three hours. We note that same values appear continuously for more than several days. The reason is that IR calibration table is produced once a day, but if a difference between the new table and the last table is less than a threshold value, the

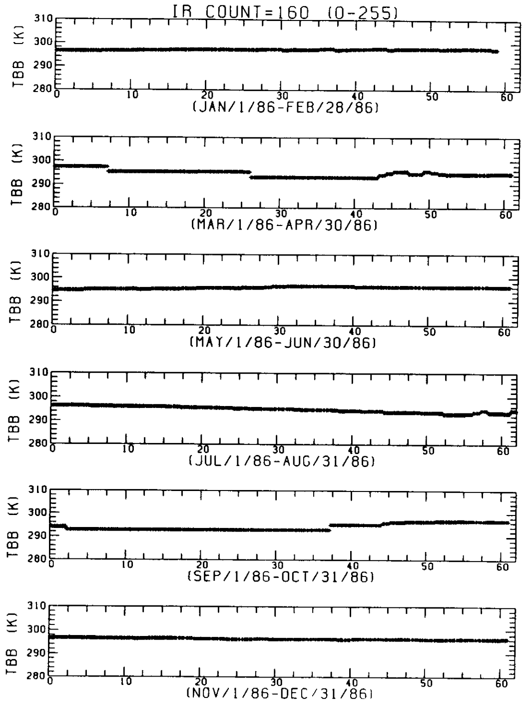

Fig. 1 Variation of brightness temperature equivalent to 160 IR count level in current operational calibration table, 1986.

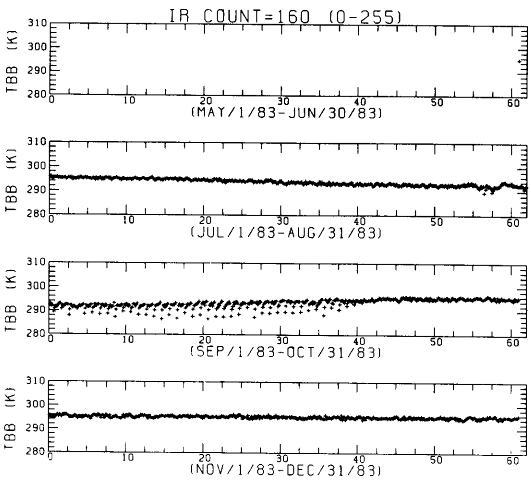

Fig. 2 (a) Variation of brightness temperature equivalent to 160 IR count level in reproduced calibration tables, 1983.

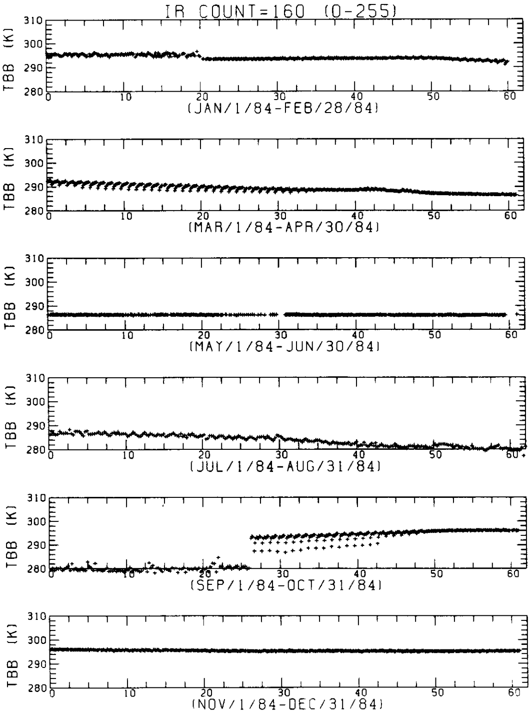

Fig. 2 (b) Same as Fig.2(a), but for 1984.

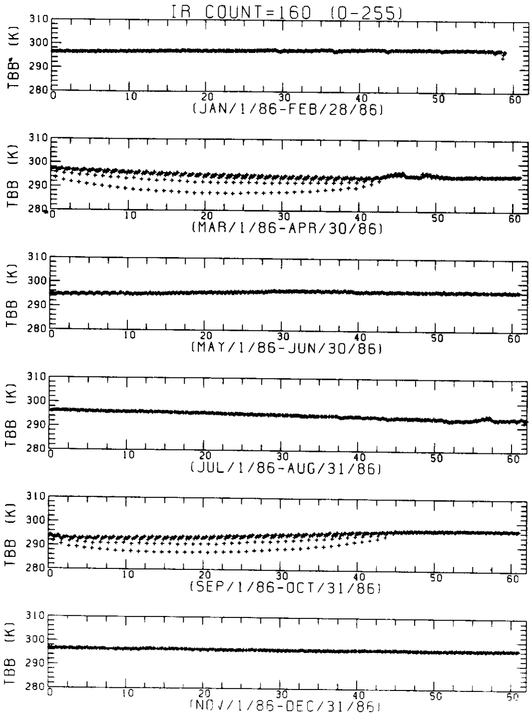

Fig. 2 (d) Same as Fig.2(a), but for 1986.

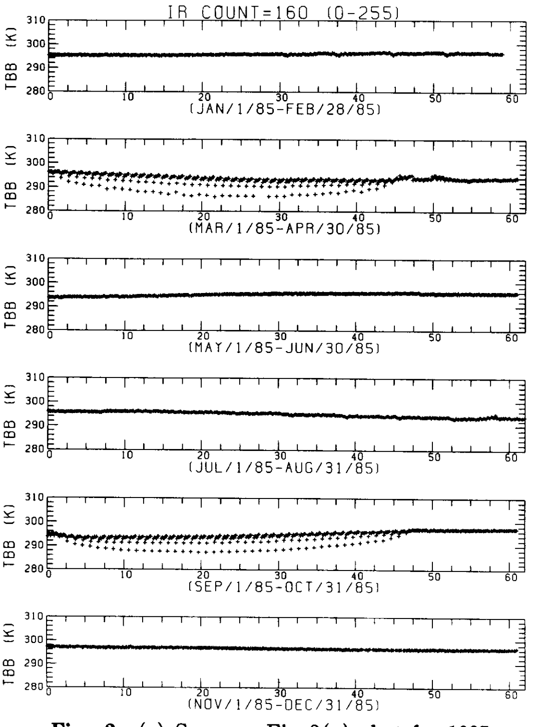

Fig. 2 (c) Same as Fig.2(a), but for 1985.

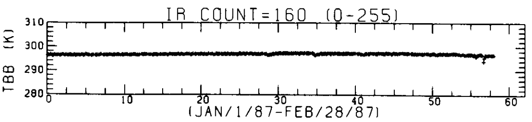

Fig. 2 (e) Same as Fig.2(a), but for 1987.

last table is not updated and continously used for the following 24 hours.

The reproduced IR calibration tables are shown in Fig.2. The description is the same as Fig.1. During eclipse periods, a diurnal variation is very clear. A rapid decrease of brightness temperature, about 6K appears between 12 and 16GMT observation. It means that IR sensor becomes more sensitive after an eclipse being cooled by lack of solar radiation. And continuous low temperatures at 18GMT suggest that it takes several hours for the IR sensor recovery. When the IR sensor becomes more sensitive, observed IR count level should become higher than in the normal condition. If a decrease of brightness temperature (160 level) is 6K, an expected increase is about 12 counts.

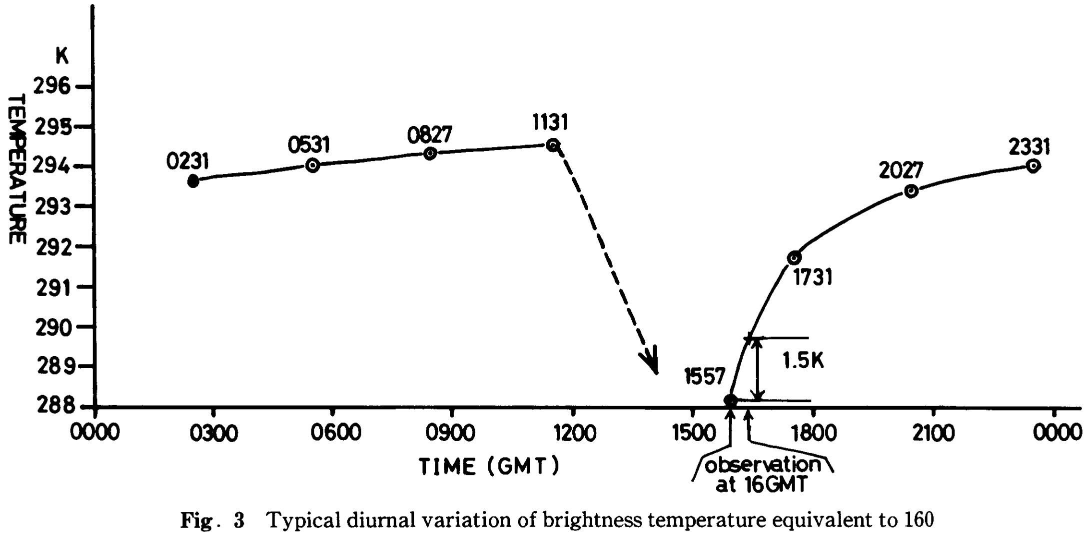

Fig. 3 Typical diurnal variation of brightness temperature equivalent to 160 IR count level during eclipse period (Sept 23, 1986)

Indeed, according to an analysis of IR images prepared by Dr.Rossow (private letter 1988), an increase of IR count from 12GMT to 16GMT is about 9 counts (about 4.5K) over water region in clear condition. But it is less than the decrease (6 K) in a calibration table. One of reasons for the difference is rapid change of IR sensor within the observation time (about 25 minutes) due to the heating after eclipse. Fig.3 shows a typical diurnal variation of brightness temperature (160 count) during an eclipse period. Strictly speaking, IR calibration table should be used for the beginning part of a full disk image because calibration data are taken at the beginning of the observation. But the representative time of full image should be the middle of a observation. So, by concerning the time lag (12 minutes), the decrease of brightness (6 K) is diminished to about 5K.

During non-eclipse periods, brightness temperatures dose not change much and diurnal variation is not clear.

The difference of reproduced IR calibration tables from the current tables is shown in Fig.4. During non-eclipse period, the difference of GMS and GMS-3 is less than IK and the difference of GMS-2 is less than 2K. But the difference reaches

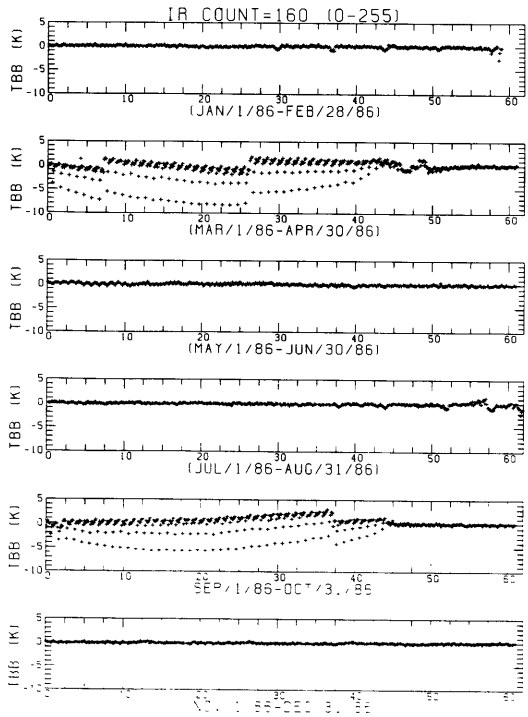

Fig. 4 Variation of the difference of a reproduced calibration temperature from a current one equivalent to 160 IR count lovel 1986.

about 6K at 16GMT during eclipse period.

To cope with such insufficiency on operational IR calibration procedure, new procedure have been used since March 1987. In the new one, an operational calibration table is calculated from 8-day mean calibration data taken at the same time for the last eight days.

GMSの赤外キャリブレーションテーブルの再作成

佐々木 秀行
気象衛星センターシステム管理課

1983年7月から1987年2月までのすべてのGMSの赤外画像について、キャリブレーションテーブルを作り直した。従来のテーブルは1日1回しか作成されていなかったため、このテーブルでカウント値を輝度温度に変換すると、センサーの日変化を較正することができなかった。実際に春と秋の食期間中に、晴れた海面の輝度温度が不自然な日変化を示していた。再作成したキャリブレーションテーブルを用いることで、これらのセンサーの変動に対応することができる。