Difference of GMS-2's Albedo between 1983 and 1984

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The meeting on International Satellite Cloud Climatology Project (ISCCP) data management was held in Paris, and G. Terry at the ISCCP Satellite Calibration Center (SCC) reported that a large change in normalization coefficients for GMS-2 occured in September 1984. In order to investigate a difference of GMS-2's albedo between 1983 and 1984, we compared visible radiances collected for central Australia in July, August and September 1983 and 1984, and confirmed the change in normarization coefficients. W. B. Rossow at the Global Processing Center (GPC) also confirmed this change by means of comparing some sample histograms of the visible counts and "albdeo" in September 1983 and 1984. The following is our investigation and results.

Neglectinng offset output voltage for simplicity, the relationship between albedo and the sensor output voltage is approximately written as follows,

$$V \cong \alpha_0 \cdot A \tag{1}$$

where V is the sensor output voltage and A is albedo. α_0 is from definition,

$$\alpha_0 = \frac{1}{A_{sn}}\left(\frac{C_{sn}-\beta_0}{\beta_1}\right)^2 \cong \frac{1}{A_{sn}}\left(\frac{C_{sn}}{\beta_1}\right)^2.$$

Using the values in 1983 (see the Table 1), α_0 is

$$\alpha_0 = \frac{1}{0.425}\left(\frac{49}{28.375}\right)^2 = 7.02.$$

Table 1 Parameters for visible caliblation and normalization procedure. Note that the GMS visible channel #6 is not used for the failure of the detector.

		GMS-1	GMS-2			GMS-3
OPERATION PERIOD		78. 4. 1. 00 Z ~81. 12. 21. 06 Z 84. 1. 21. 09 Z ~84. 6. 29. 12 Z	81. 12. 21. 09 Z ~84. 1. 21. 00 Z 84. 6. 29. 18 Z ~84. 9. 27. 00 Z			84. 9. 27. 06 Z ~UP TO DATE
SENSOR		REDUNDANT	PRIMARY			REDUNDANT
REFERENCE CHANNEL		CHANNEL #7	CHANNEL #1			CHANNEL #5
$C=\beta_0+\beta_1*\sqrt{V}$	β_0	−0. 23764	−0. 309			−0. 1321
	β_1	27. 728	28. 375			28. 37
SUN COUNT VALUE		33	81. 12. 21~ -48	82. 9. 7~ -49	84. 6. 29~ -30	42
SPACE COUNT VALUE		1	1	1	1	1
SUN ALBEDO (A_{SN})		30%	55%	42. 5%	48%	45%

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Table 2 Observed Count Values of Reflected Light from Austlalian Inland Surface.

	20°S, 135°E	25°S, 135°E	30°S, 135°E
1983 July 15 06Z	17	17	17
Aug. 13 06Z	18.5	19	18
Sep. 16 06Z	19	19.5	19.5
1984 July 16 06Z	11	12	11
Aug. 15 06Z	12	13	12
Sep. 17 06Z	12	13	13(Sep. 16)

The data are extracted from the histogram data in the target area. The histogram peak, which is composed of the data reflected from the ground, appears in the lower level part of histogram and we adopt the mode value of histogram as the data reflected from the ground.

Since July 1984, the observation was performed with lowering the gain of GMS-2 visible sensors; nominal lowering was -6 dB. It was, however, estimated from the radiances reflected by Australian inland surface,

$$r=\frac{V'}{V}=0.440\pm0.028$$

where r is the ratio of voltage V' and V in two periods (see Tables 2 and 3). The above $r=0.440$ corespond to -7.13 dB.

Therefore, the sensor output voltage should have been converted into albedo in July, August and September 1984 using the following equation,

$$V=r\cdot\alpha_0\cdot A=\alpha_0'\cdot A \qquad (2)$$

where $\alpha_0'=7.02\times0.440=3.09$.

Actually, it was converted since July 1984 using the following equation,

$$V=\alpha_0''\cdot\alpha \qquad (3)$$

where 'a' is actually derived albedo and A_0'' is

$$\alpha_0''=\frac{1}{0.48}\left(\frac{30}{28.275}\right)^2=2.33$$

(see Table 1).

So, the relationship between albedo A in 1983 and albedo 'a' since July 1984 is, from equations (2) and (3)

$$\frac{\alpha}{A}=\frac{\alpha_0'}{\alpha_0''}=\frac{3.09}{2.33}=1.33 \qquad (4)$$

On the other hand, from the realtion $Y=A\cdot X+B$ between albedos of NOAA-7 and GMS-2, we get

Table 3 Ratio of Sensor Gain (ratio of sensor output voltage).

	20°S, 135°E	25°S, 135°	30°S, 135°E
July	0.419	0.498	0.419
Aug.	0.421	0.468	0.444
Sep.	0.399	0.444	0.444

Mean value $\overline{\left(\frac{V'}{V}\right)}=0.440$, RMS $\sigma=0.028$

Sensor output voltage and count value are related by the following equation,

$$C=\beta_0+\beta_1\sqrt{V}.$$

Ratio of sensor output voltage is written as follows,

$$\frac{V'}{V}=\frac{\left(\frac{C'-\beta_0}{\beta_1}\right)^2}{\left(\frac{C-\beta_0}{\beta_1}\right)^2}\cong\left(\frac{C'}{C}\right)^2.$$

$$\frac{X'}{X} = \frac{Y-B'}{A'} \cdot \frac{A}{Y-B} \cong \frac{A}{A'}$$

$$\cong \frac{(1.132+1.093+1.121)/3}{0.895} = 1.25 \quad (5)$$

where X' is albedo in 1983 and X is albedo since July 1984 (see Table 4).

We can clarify the difference of coefficients A in two periods, with some torerable discrepancy.

Table 4 Coefficients of normalization for visible channel compared with NOAA 7 channel 1. $Y=AX+B$ where Y is the reflectance as measured in AVHRR channel 1 abd X the reflectance as measure by GMS. (after G. Terry, 1985)

MONTH	GMS 2			GMS 1			GMS 2	GMS 3	
	JULY 83	OCTOBER 83	JANUARY 84	FEBRUARY 84	MARCH 84	APRIL 84	SEPTEMBER 84	OCTOBER 84	JANUARY 85
SLOPE A (σ_A)	1.132 (0.015)	1.093 (0.023)	1.121 (0.021)	1.328 (0.013)	1.341 (0.006)	1.334 (0.016)	0.895 (0.006)	0.991 (0.008)	1.028 (0.004)
INTERCEPT B (σ_B)	0.003	0.026	0.013	−0.003 (0.003)	−0.004 (0.001)	−0.004 (0.004)	−0.015 (0.002)	−0.014 (0.003)	−0.023 (0.003)

1983年と1984年における GMS 2号のアルベドの差について

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1986年6月にパリで開かれた国際衛星雲気候計画（ISCCP）の会議で衛星較正センター（SCC）のG. Terryによって1984年のGMS-2のNOAA-7号に対する規格化定数が1983年のものと大きく違うことが指摘された。この原因について調査した。その結果，1984年7月～9月にかけては，可視センサーの利得を－6 dB下げて運用していたが，センサーの出力電圧をアルベドに変換するときの定数が不適当であったため1984年7～9月のGMS-2のアルベド値が高くなったことがわかった。このアルベド値の増加は，G. Terryの指摘した値とほぼ合っていた。また，全球処理センター（GPC）のW. B. RossowによってもSCCの結果を支持する調査結果が示されている。