

Partial Level Down in Brightness of Geostationary Meteorological Satellite (GMS) Infrared (IR) Images Caused by the Moon

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Abstract

The phenomena of partial level down in GMS VISSR IR brightness occurred when VISSR happened to view the moon during the IR channel DC restoration, and were examined using the VISSR image data of 1979.

It becomes clear from the study that the phenomena may occur semimonthly with 5 days duration each and the affected pictures sum up to about 80 a year. The level down magnitude depends upon both the moon's phase (the moon's age) and the moon's east-westward location in the DC restoration domain viewed from VISSR. Therefore, particularly large level downs occur in cases where the both conditions coincide with each other, however, they are only a few times a year. The occurring time of day, the position of VISSR scan lines and the magnitude are rather at random owing to the orbital motions of the moon and the space-craft.

1. Introduction

Level downs in GMS VISSR IR brightness occur to the extent of a maximum width of about 60 scanlines, when VISSR is viewing the moon during the IR channel DC restoration. The same phenomena were reported in SMS and GOES.

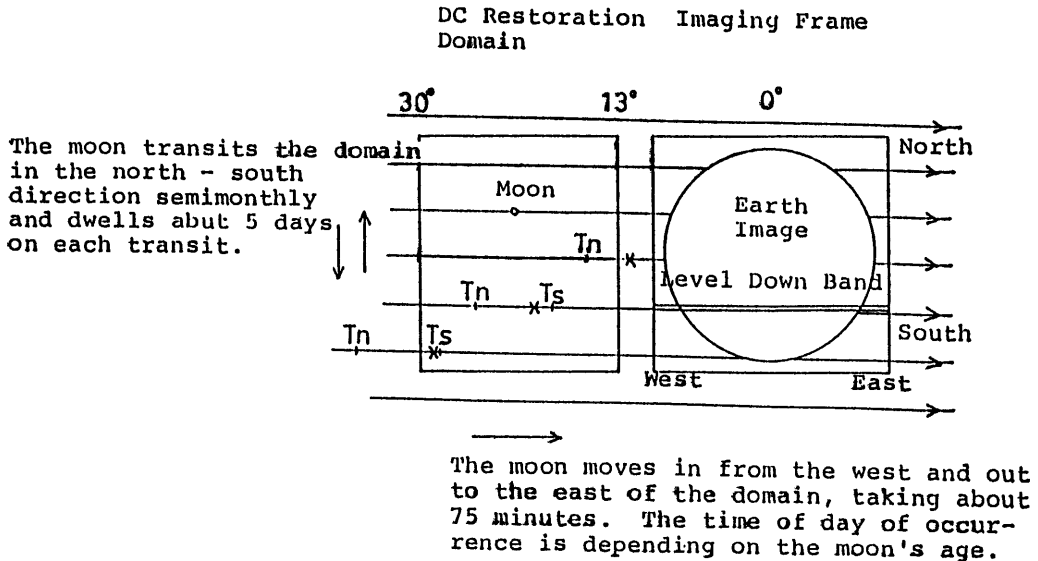
While VISSR images are being taken, the VISSR AC-coupled amplifier for IR channel adjusts the IR channel's brightness level, that is, it restores the base line of the AC-coupled signals to a reference voltage at each scan line (DC restoration). This DC restoration is made based on the radiation level of the space between 30° and 13° prior to scanning the earth center. If the moon is scanned during the restoration, the adjusted level is higher than normal space level. It causes

the level down in IR brightness on the scan line (Fig. 1). Eventually, brightness level down occurs in a band pattern corresponding to the effective diameter of the moon, which is the widest when the moon is near the full.

2. Timing of the Level Down Occurrence

These phenomena semimonthly occur during the period of 5 days while the moon goes across the VISSR visual angle of about 20° from north to south or vice versa (Fig. 2). At present this period is 5 days, but it varies on account of the precession of the moon's orbital plane on a 10-odd-year cycle. During this 5-day period, once a day the moon goes across the VISSR DC restoration domain from west to east taking about 1 hour and 15 minutes as the space-craft revolves. The moon's transit time of day

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Note: T_n - Time of VISSR scanning the north edge.
 T_s - Time of VISSR scanning the south edge.
 X - Moon's location when VISSR scans the moon.

Fig. 1 The Periodical Appearance of the Moon in the IR DC Restoration Domain.

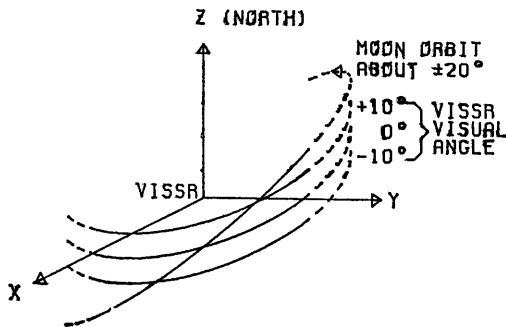


Fig. 2 The VISSR north-southward visual Angle and the Moon's orbital Motion.

across the DC restoration domain nearly corresponds to the moon's phase at that time (Fig. 3): when the moon is near the full, it is around the local noon; when the moon is near the prime, it is around the midnight. If VISSR images are taken while the moon is going across the domain, the brightness level down occurs from the mis-restoration.

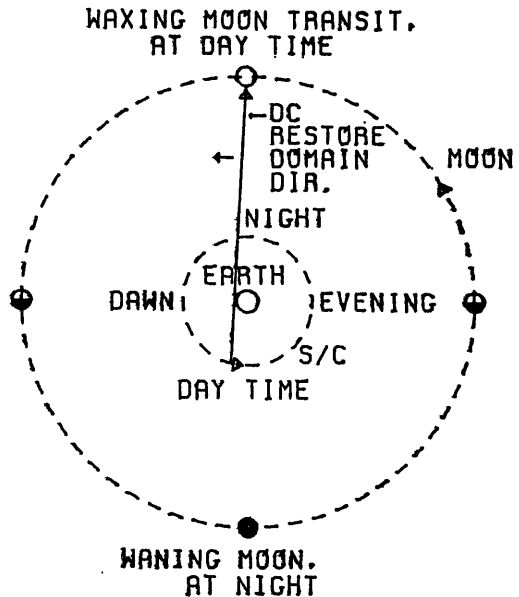


Fig. 3 The Relation between the Moon's Phase and the Hour of the Moon's east-westward Transit across the DC Restoration Domain.

3. Magnitude and Frequency of Occurrence

Normally, GMS VISSR images are taken 14 times a day, so that the frequency of occurrence of the phenomena is estimated to be about 3 times on an average for each 5-day period, and amount to about 80 times a year.

The magnitude of the level down depends upon both the moon's phase and the moon's location in the east-west direction in the DC restoration domain at the time when the level down occurs. Fig. 4 shows level down data for 1979. The following facts are clearly illustrated by the figure.

- (1) As to the moon's phase (the moon's age)

A large magnitude of the level down occurs when the moon is near the full. As the moon is on the wane, it becomes smaller. This shows that large level downs appear

only in the images taken in the daytime (cf. the preceding chapter) when the moon is near the full.

- (2) As to the moon's location in the east-west direction in the DC restoration domain

The largest magnitude of the level down appears when the moon is at the extreme east of 13° or vicinities in that domain in east-west direction (it corresponds to the last stage of the DC restoration, in terms of time), and the magnitude becomes rapidly small as the moon's position in that domain becomes more westwards.

Particularly large level downs are observed when the two conditions mentioned above occur simultaneously. This kind of large level downs occur only a few times a year. The smaller level downs occur more frequently. From the data as shown in Fig. 4, the frequency of occurrence of the level

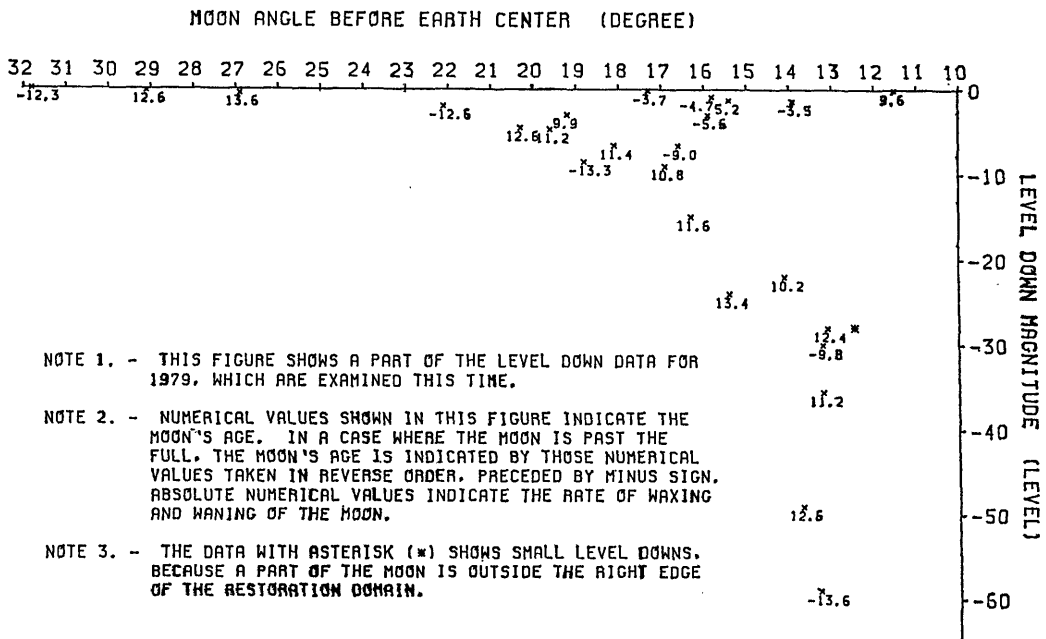


Fig. 4 The Level Down Magnitude related to the Moon's eastwestward Location in the DC Restoration Domain and to the Moon's Phase at that Time.

downs of more than 10 IR brightness levels is estimated to be about 10 times a year, and those of more than 5 levels, about 15 times a year, on an average.

4. Variation of Occurrence of the Phenomena

These phenomena occur with both regular and irregular variations corresponding to the moon's transit across the DC restoration domain viewed from VISSR. This situation of occurrence is originated mainly from 2 components of the moon's orbital motion :

(1) the east-westward motion which determines both the moon's transit time of day across that domain (to put it another way, the moon's location in the east-west direction in that domain at a certain time) and the moon's phase;

(2) the north-southward motion which determines the position of the affected lines of the VISSR image and the appearance of the 5-day affection period. This motion also determines the moon's location in the east-west direction viewed from VISSR because of the time span between the VISSR's first scanning and scanning the moon.

The hourly and daily variations during each 5-day period of occurrence of the phenomena are shown in Fig. 1 and 7. In these variations, the moon's location in the east-west direction in that domain and the moon's phase are shifted rather regularly, so the affected time of day and the position of the scan lines vary regularly. However, the magnitude of the level downs extremely varies according to the moon's east-west location in that domain.

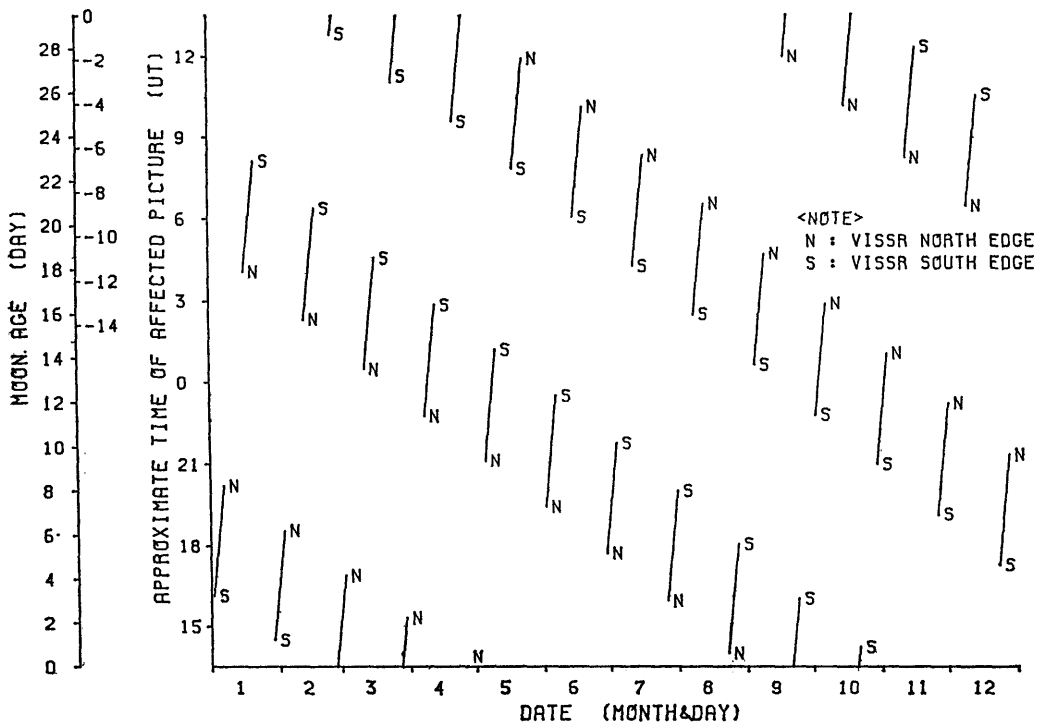


Fig. 5 Durations of the Moon's north-southward Transit across the VISSR visual Angle and the Moon's Phase at that Time, for 1979.

The monthly variations of the phenomena are shown in Fig. 5 and 6. According to the moon's orbital motion, the level downs occur almost periodically. However, the cycle of the movement of the moon in the east-west direction (a lunar month) is asynchronous with the space-craft orbital motion, at monthly intervals, and also with the movement of the moon in the north-south direction which corresponds to the moon's sidereal revolution. This asynchronism causes considerable variations in the moon's east-westward location in the DC restoration domain, hence the magnitude of the level down phenomena varies very much. Further, in terms of the moon's phase, owing to the asynchronism between the cycles of the two components of the moon's motion, the moon's phase for the 5-day period in question varies considerably every month. This causes variations in the magnitude of the level downs, and makes the phenomena more complicated.

The yearly variations of the phenomena are also very large because of the yearly asynchronism between the motions of the moon and the space-craft, while the relation between the moon's phase (the moon's age)

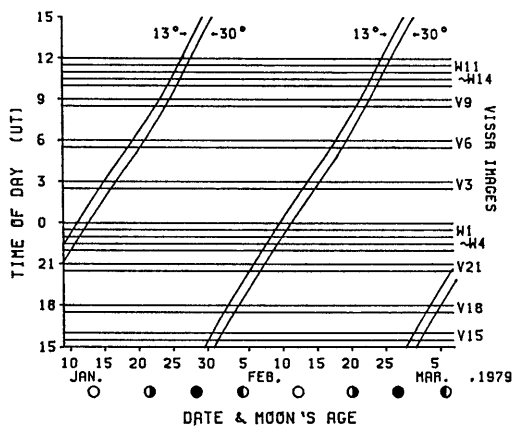


Fig. 6 Periodical Variations at monthly Intervals of the Hour of the Moon's east-westward Transit across the DC Restoration Domain.

and its north-southward motion as shown in Fig. 5 is almost the same at the same time each year.

5. The Sun and the DC Restoration

The sun goes across the 30°-13° direction DC restoration domain at about 13-14 UT. However, at that time the DC restoration domain is shifted to other angular portion automatically by the space-craft onboard mechanism. Therefore the level down phenomena by the sun never occur.

6. Prediction of the Phenomena

The date and time of occurrence and the

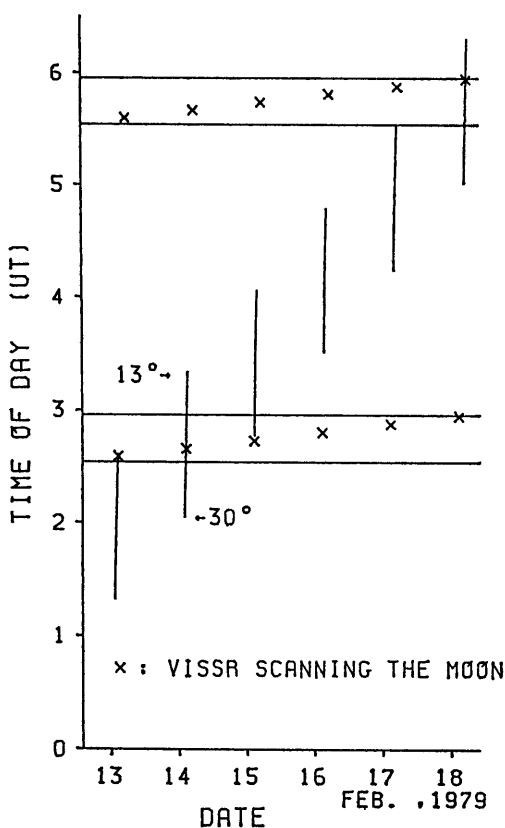


Fig. 7 Detail Variations with Day of the Hour of the Moon's east-westward Transit across the DC Restoration Domain during the days of its north-southward Transit across VISSR visual Angle (An Enlargement of Fig. 6)

degree of the level down owing to the moon's phase can be predicted roughly by the moon's orbital data as shown in Fig. 5. The precise predictions of the day, the time, the position of the affected scan lines and the magnitude can be obtained from the moon's location viewed from VISSR, using the estimated space-craft's orbital and attitude parameters and the moon's orbital data. The

accuracy of the one month prediction of the moon's east-westward location viewed from VISSR is about $\pm 0.1^\circ$, which is a satisfactory value as the prediction of the phenomena.

Postscript

This paper was prepared early in 1980. At present the same level down phenomena are also observed in GMS-2.

月による GMS の赤外画像における輝度の部分的レベル低下について

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要 旨

GMS の VISSR が DC リストアのときに月を見ることによって赤外画像に生じる輝度の帯状のレベル低下の現象について、1979年の1年間のデータを使って調べた。この解析によって以下のことが明らかとなった。このレベル低下の現象は、低下量の小さいものも含めれば、約半月毎の5日間に起り、その頻度は1年間に数十回に達する。そのレベル低下量は、その時の月の満ち欠けと DC リストア領域内の月の位置に依存して決まる。したがってこの2つの条件が一致した時に特に大きなレベル低下が起きるが、こうしたケースは1年に数回あるだけである。また、この現象は月と衛星との運動によって非常に不規則に起きるが、かなり正確に予測することが可能である。