INTRODUCTION OF NUC ALGORITHM IN ON-BOARD RELATIVE RADIOMERIC CALIBRATION OF KOMPSAT-2

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ABSTRACT:

The KOMPSAT-2 satellite is a push-broom system with MSC (Multi Spectral Camera) which contains a panchromatic band and four multi-spectral bands covering the spectral range from 450nm to 900nm. The PAN band is composed of six CCD array with 2528 pixels. And the MS band has one CCD array with 3792 pixels. Raw imagery generated from a push-broom sensor contains vertical streaks caused by variability in detector response, variability in lens falloff, pixel area, output amplifiers and especially electrical gain and offset.

Relative radiometric calibration is necessary to account for the detector-to-detector non-uniformity in this raw imagery. Non-uniformity correction (NUC) is that the process of performing on-board relative correction of gain and offset for each pixel to improve data compressibility and to reduce banding and streaking from aggregation or re-sampling in the imagery. A relative gain and offset are calculated for each detector using scenes from uniform target area such as a large desert, forest, sea.

In the NUC of KOMPSAT-2, The NUC table for each pixel are divided as HF NUC (high frequency NUC) and LF NUC (low frequency NUC) to apply to few restricted facts in the operating system of KOMPSAT-2.

This work presents the algorithm and process of NUC table generation and shows the imagery to compare with and without calibration.

1. INTRODUCTION

KOMPSAT-2 has a main payload MSC (Multi Spectral Camera) with 1m resolution Panchromatic and 4m Multi-spectral bands. The PAN band is composed of six CCD array with 2528 pixels. And the MS band has one CCD array with 3792 pixels.

channel	PAN	MS1	MS2	MS3	MS4
GSD(m)	1	4	4	4	4
Spectral Range(nm)	500 ~900	450 ~520	520 ~600	630 ~690	760 ~900

Figure 1. Performance of KOMPSAT-2 MSC

Since push bloom imaging by TDI detector, NUC table have to be generated as each TDI level.

Regular NUC table generation method and procedure are as follows:

1) Illuminate all pixels by uniform illumination
2) Collect pixel data for ~25% of saturation illumination
3) Collect pixel data for ~75% of saturation illumination
4) Generate NUC table for all PAN and MS channel with each TDI level using NUC table generation algorithm
5) Update on board NUC table

2. NUC ALGORITHM FOR KOMPSAT-2

The NUC table on KOMPSAT-2 operation system are comprised of several components as follows:

- The low frequency table consisting of gain values, for each TDI mode and each Pan detector,
- The high frequency table consisting of gain and offset values, for each TDI mode and each Pan detector,
- The high frequency table consisting of gain and offset values, for each TDI mode and each MS detector,

Gain values must exceed 1 and offset values must be nonnegative.

2.1 Low Frequency NUC Table for the butting zone

Obtain from the user the payload overlap point. Using linear approximation, obtain the straight line connecting the ends of the overlap zone. The linear equation gives the desired pixel values at low frequency.

$$A \cdot i + B$$

where i is the pixel number, A is the slope, B is the intercept.

The low frequency gain is the V_{mean} value relative to the value calculated by the linear formula as follows:

$$G_{LF}[i] = \frac{V_{mean}}{A \cdot i + B}$$

where $G_{LF}[i]$ is the low frequency gain for the ith pixel,
V_{mean} is calculated in paragraph,
A is the slope
B is the intercept

For vector L[i] obtained at low illumination, use A, B multiplied relative to the illumination level, as follows:

$$A_L = A_H \cdot \frac{I_L}{I_H}$$

where I is the illumination intensity.

The gain should remain the same at either illumination intensity due to V_{mean} changing proportionally to the illumination intensity.

2.2 Low Frequency NUC Table for the full-signal zone

We use a smoothing filter N around a given pixel. We also use the values obtained at high illumination V_H. The filter will slide along the pixels in the vector V_H beginning at the Nth pixel from each end after excluding pixels in the overlap zones. The filter will provide a simple average of the included pixel values. The pixels in the overlap zones and those before applying the filter will be replaced using linear extrapolation. The resulting vector W_H will contain the smoothed values. The value V_{mean} will be assigned the maximum value found in vector W_H.

The low frequency gain is the V_{mean} value relative to the smoothed vector values for each pixel as follows:

$$G_{LF}[i] = \frac{V_{mean}}{W_H[i]}$$

where $G_{LF}[i]$ is the low frequency gain for the *i*th pixel,
V_{mean} is the maximum value found in vector $W_H[i]$,
$W_H[i]$ is the smoothed value for the *i*th pixel

The low frequency gain should remain the same even for low illumination.

2.3 High Frequency NUC Table

This table contains both gain and offset values.

2.3.1 High frequency gain calculation

Multiply all the values (overlap and full-signal zones) in the measured pixel value vectors by the appropriate low frequency gain values as follows:

$$U_H[i] = H[i] \cdot G_{LF}[i]$$

and

$$U_L[i] = L[i] \cdot G_{LF}[i]$$

The high frequency gain is the D_{max} value relative to the calculated pixel differences as follows:

$$G_{HF}[i] = \frac{D_{max}}{D[i]}$$

where $G_{HF}[i]$ is the high frequency gain for the ith pixel,
D_{max} is the maximum pixel value in D[i],
D[i] is the pixel value difference for the ith pixel
$G_{HF}[i] \geq 1$ for all i values

2.3.2 High frequency offset calculation

Use the high frequency gain values calculated in step 0 and multiply them by the smoothed pixel values obtained at low illumination.

Calculate the offset values as follows:

$$Off[i] = T_{max} - T_L[i]$$

where Off[i] is the offset for the ith pixel,
T_{max} is the maximum value in $T_L[i]$

2.4 NUC Application

In order to correct the sampled pixel values using the NUC table,apply the following:

$$Y[i] = V[i] \cdot G_{LF}[i] \cdot G_{HF}[i] + Off\{i]$$

where Y[i] is the corrected ith pixel value
V[i] is the sampled ith pixel value, sampled at any illumination level,
$G_{LF}[i]$ is the low frequency gain for the ith pixel,
$G_{HF}[i]$ is the high frequency gain for the ith pixel,
Off[i] is the offset for the ith pixel

3. APPLICATION AND RESULT

In order to generate NUC table, we use multi-sources reference data with various DN levels from uniform are such as desert, forest, sea, etc.

3.1 Full-signal Zone

Figure 2. Original Image
This Image is the original non-uniform sequence. The non-uniformity patterns are clearly visible.

Figure 3. Corrected Image

This Image is the same image after the application of NUC table based corrected algorithm.

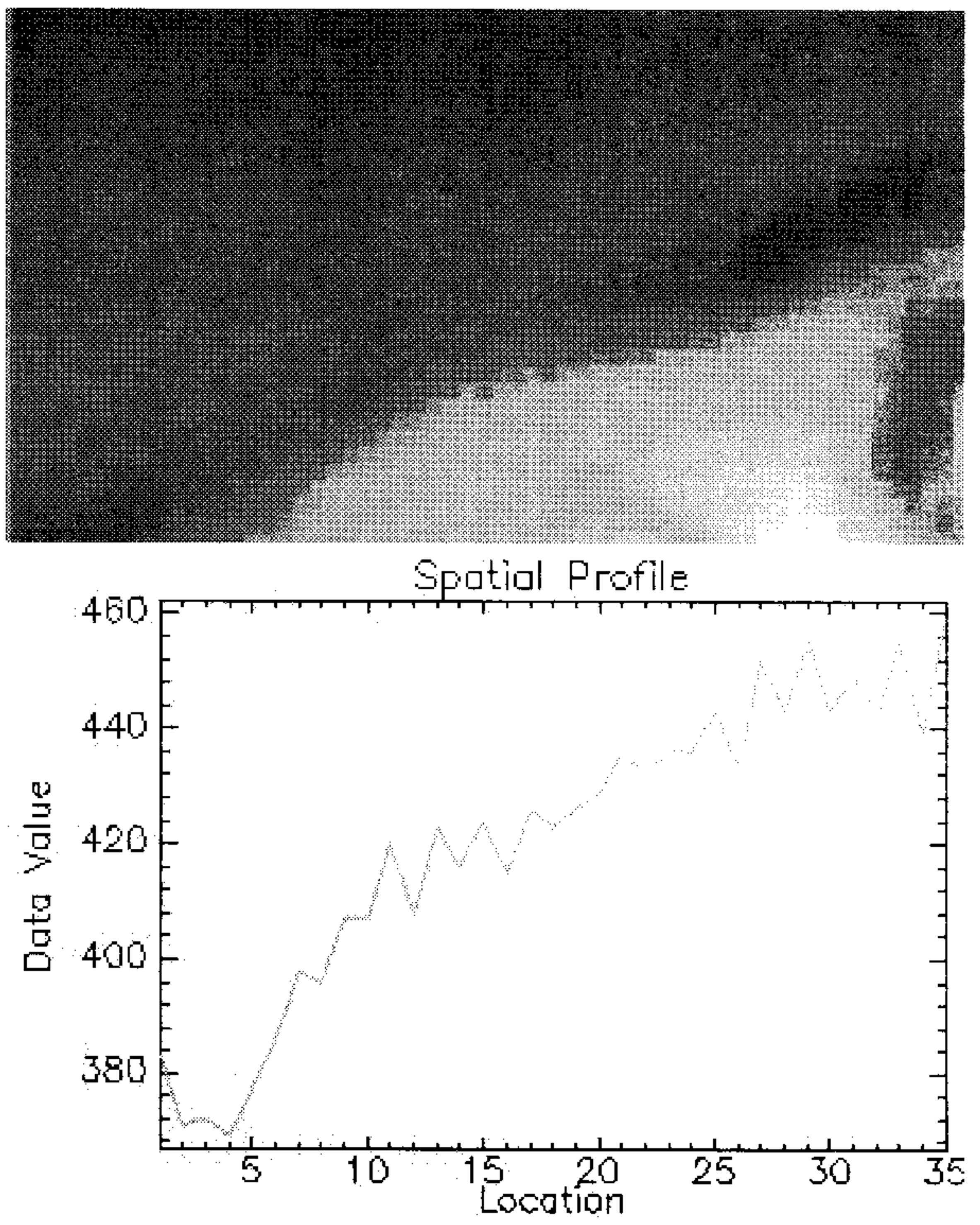

Figure 4. Original Image and Profile
This Image shows the non-uniformity noise and its spatial profile of horizontal axis.

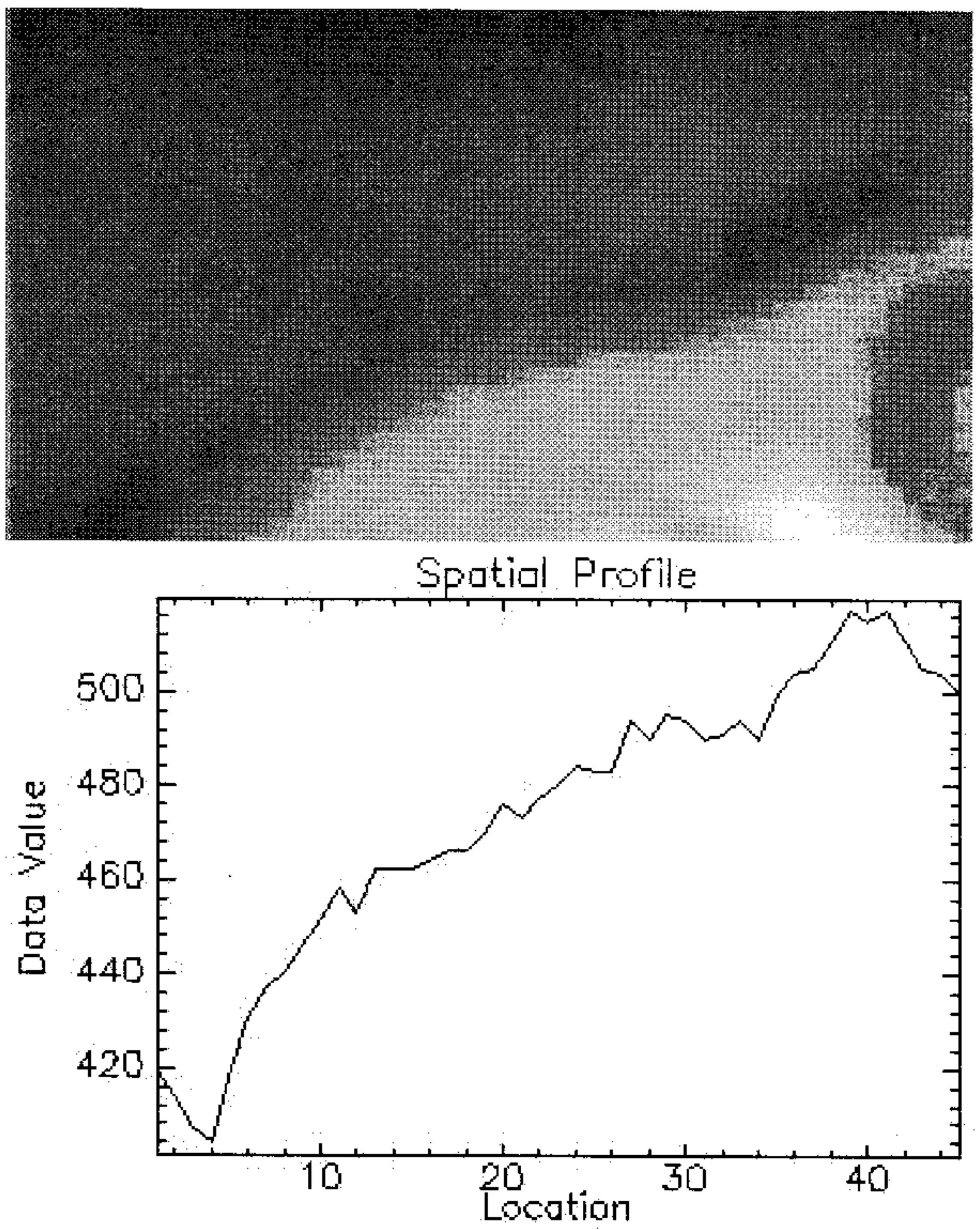

Figure 4. Original Image and Profile
This Image shows the non-uniformity noise and its spatial profile of horizontal axis.

3.2 Butting Zone

KOMPSAT-2 has six panchromatic bands whose order is PAN1, PAN2, PAN4, PAN3, PAN5, PAN6. There are two butting zones in the panchromatic band 2 & 4 and 3 & 5.

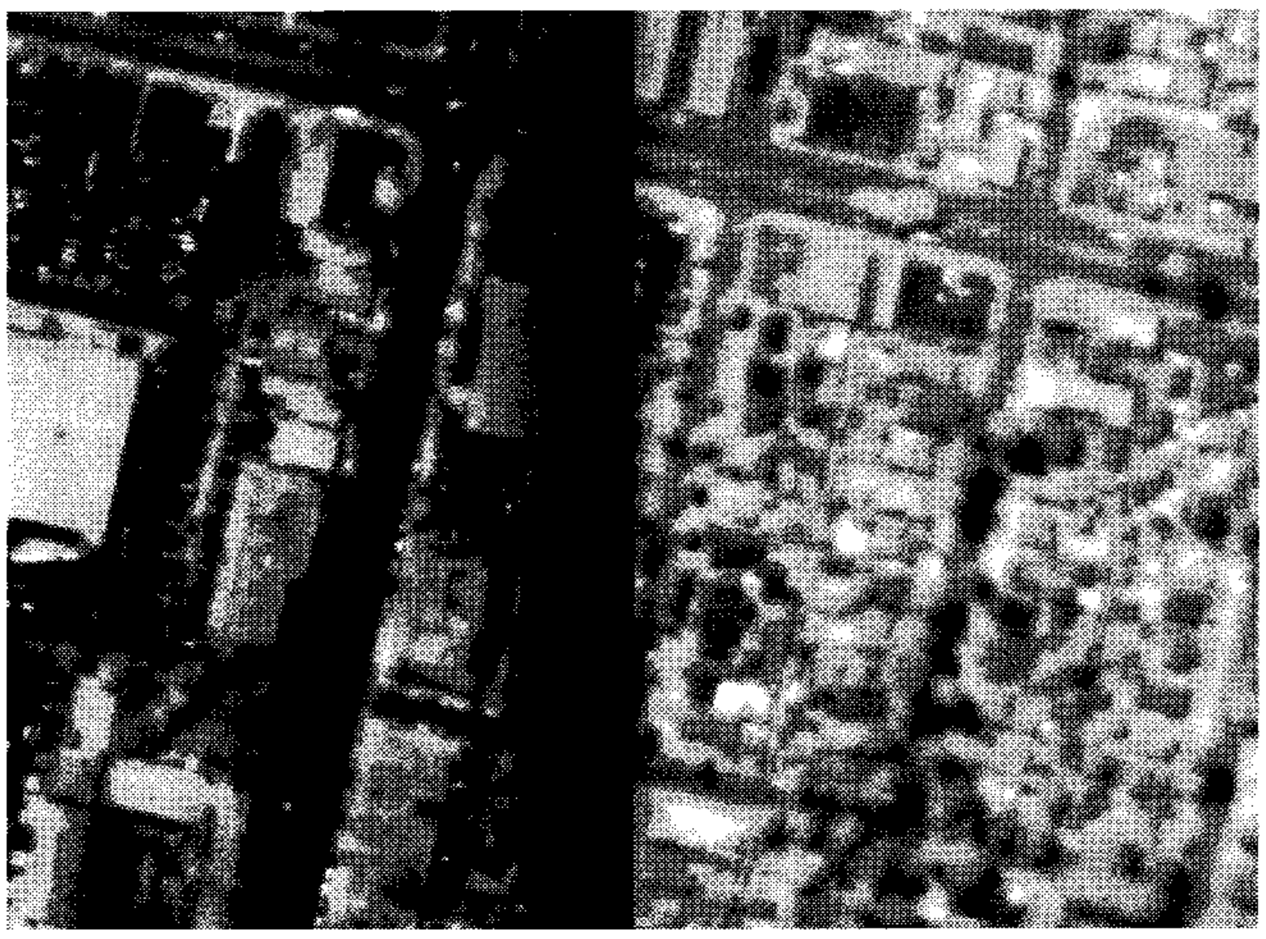

Figure 5. Original Image (PAN2 & PAN4)
This Image is the original abnormal pattern in the butting zone of panchromatic band 2 and 4.

Figure 6. Corrected Image (PAN2 & PAN4)

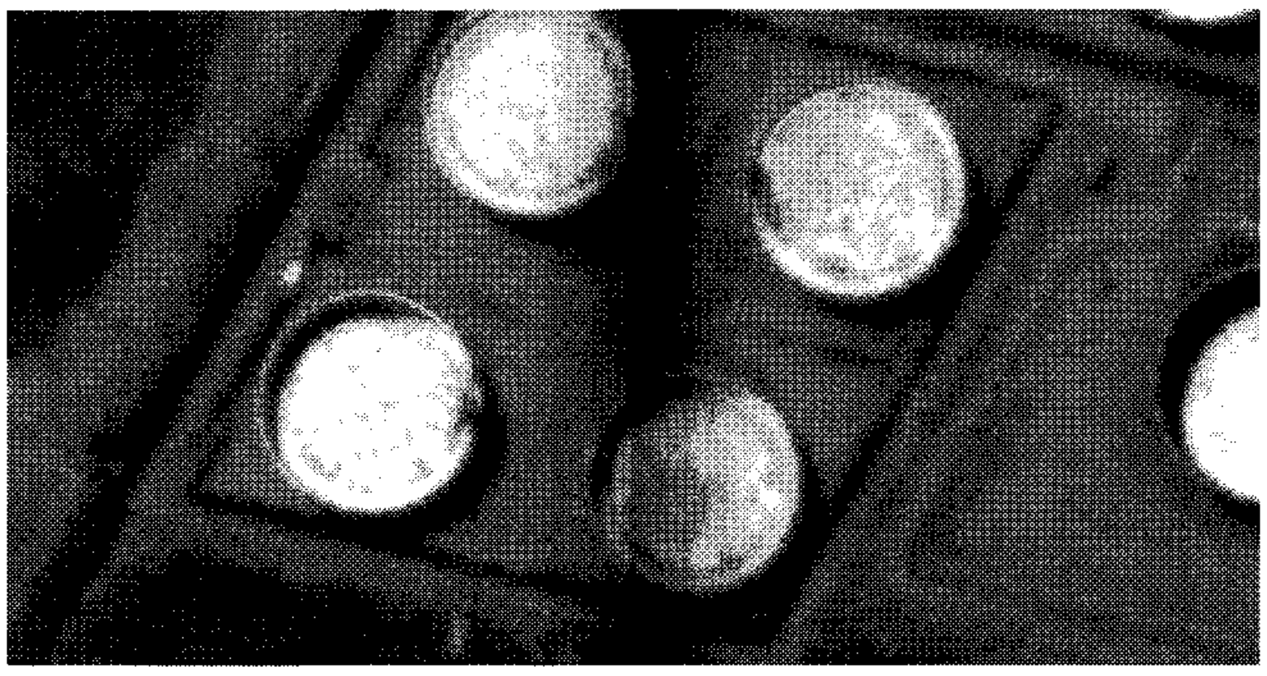

Figure 7. Original Image (PAN3 & PAN5)

This Image is the original abnormal pattern in the butting zone of panchromatic band 3 and 5.

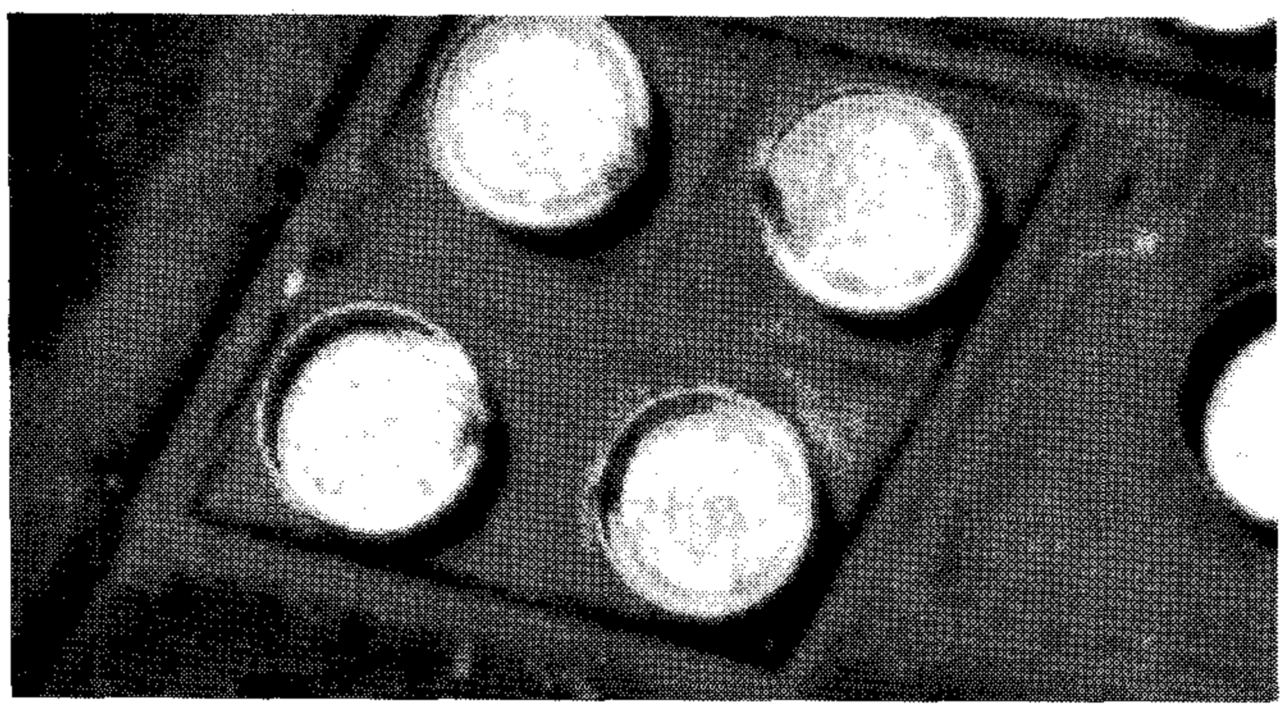

Figure 8. Corrected Image (PAN3 & PAN5)

4. SUMMARY

This document introduces an algorithm to correct the non-uniformity of KOMNPSAT-2 imagery.

Our correction algorithm is not statistical method which use a large number of lines on the assumption that the NUC is of a linear nature but scene based method which use multi point to cover various DN level using a series of uniform imagery collected between October of 2006 and April of 2007. And our process are divided into two terms as HF NUC (high frequency NUC) and LF NUC (low frequency NUC) to apply to few restricted facts in the operating system of KOMPSAT-2.

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