Relative Calibration of the CBERS-2 CCD Camera

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The radiometric image quality is evaluated during the so-called in-orbit test period, in order to verify if the subsystem requirements are complied with the specification and thus to obtain the image correction parameters to be used in the ground processing center. During the satellite's operational lifetime a complete quality assessment must be performed periodically and therefore, update the parameters if necessary. The radiometry of an image is satisfactory, when the relationship between the ground reflectance of the target and the gray level of the pixel on the image is correct. One of the radiometric characteristics analysed is the relative calibration. The relative calibration process aims to correct the effects of the variability of the detector responses in the images. There are many ways to implement this process, which depends on the available calibration data. The calibration algorithm implemented in the CBERS-2 Processing Station at INPE has used the calibration data acquired by integration semi sphere (Fonseca et al, 2004). Sometimes, the simple application of CCD calibration coefficients is not sufficient to ensure all images with good quality. Therefore, a relative calibration procedure of the CBERS-2 CCD camera is presented in this paper. Some experiments are performed in order to test the methodology.

CBERS-2 satellite carries on-board a multisensor payload with different spatial resolutions: WFI (Wide Field Imager), IRMSS (Infrared Multi-Spectral Scanner) and CCD (Charge Coupled Device) camera. The high-resolution CCD Camera has 4 spectral bands from visible light to near infrared and one panchromatic band. It acquires the earth ground scenes by pushbroom scanning, on 778 km sun-synchronous orbit and provides images of 113 km wide strips with sampling rate of 20 meters at nadir. The CCD detector array arrangement consists of three arrays of 2048 detectors. During the telemetry data transmission, 6130 bytes are received in each line of the image and for each channel; 14 pixels in the third array are not received by the station. Within these data, 154 pixels in each array are superimposed and 8 pixels are dark. Figure 1 shows the detector arrangement for CBERS.

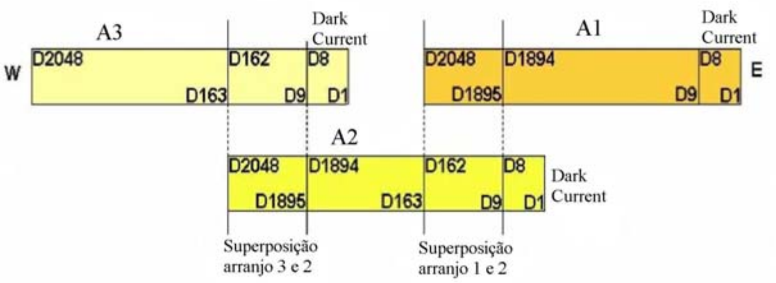


Figure 1: CCD Detector Arrangement

As we can see in Figure 1, there are two superimposed regions between the arrays (A12 and A23). Then, the final image contains 5798 pixels in a line. Any difference in calibration between these detectors, originating from factors such as power instability, will result in a noticeable difference between similar ground elements. Within each CBERS CCD array, there is an intra-detector variability, which needs to be detected and corrected. The signal is generated into 2 channels: CCD-1 (B2, B3 and B4) and CCD-2 (B1, B3 and B5). Band 3 appears in both channels.

The detector response variation is caused by basically three factors:

- A residual response for zero radiance, better known as "dark current" or "bias" or "offset", in practice, implies in a response different from zero when there is no illumination reaching the detector. This offset is unique for each detector;

- A different gain for each detector which, in practice, results in different response for each detector for the same level of radiance;

- The three detectors arrays have different average responses caused by a global gain difference among the arrays.

The relative calibration parameters are obtained as follows:

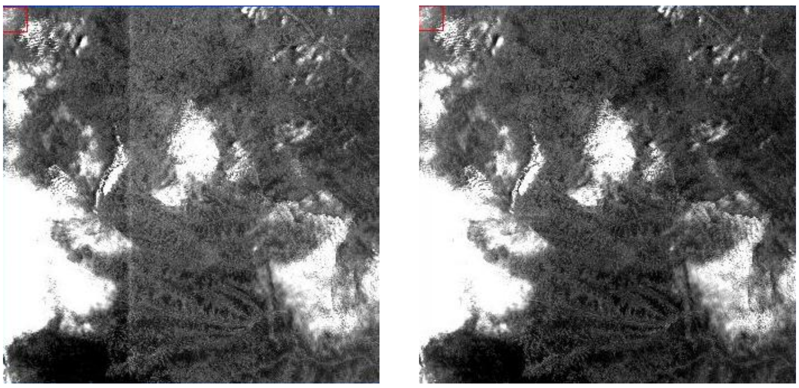
$$Y(b,a,p,g) = \frac{X(b,a,p,g) - O(b,a,p,g)}{G(b,a,p,g)} \tag{1}$$

Where *X(b,a,p,g)*: DN (Digital Number) value of the detector *p*, in the array *a* for the gain value *g*, *Y(b,a,p,g)*: corrected pixel value for detector *p* of array *a* for the gain value *g*, *O(b,a,p,g)*: dark current offset for detector *p* of array *a* and for the gain value *g*, *G(b,a,p,g)*: gain coefficients for detector *p* of array *a* and for the gain value *g*. All these parameters should be available for all spectral bands *b*. The coefficients of the equation (1) for all detectors, arrays and bands for each given instrument configuration form an "equalization coefficient set". CBERS2-CCD has 4 gains applied to each channel.

The traditional calibration method calculates the dark currents from an image with zero radiance level take it off from each pixel in the image and calculate the gain values in order to equalize the sensor responses.

The CBERS-2 CCD calibration data were obtained for 12 radiance levels (given by the semi-sphere, *L*=1,2,3…,12) and for the several configurations of the instrument gain. For each radiance level *L*, 400 lines of digital numbers were recorded for each band and array.

The calibration algorithm implemented uses the calibration data acquired by integration semi sphere. The data are saved in a file in an increasing order in relation to their intensity level. The Figure 2 shows the images before and after the relative calibration processing.



(a) (b)

Figure 2: Image of China (a) before and (b) after the relative calibration

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