6.- RADIOMETRIC CORRECTIONS

The preprocessing of satellite images involves two main groups of operations: *radiometric corrections* and *geometric corrections*. In this chapter we will introduce some of the basic models and tools used for the reduction of radiometric errors on images.

The radiometric errors are due: (1) to the influence of the scattering and absorption of the atmosphere; and (2) to the differences in calibration or operation of the sensor systems acquiring the images.

6.1.- Atmosferic corrections: A general overview.

The intensity value of a pixel is caused by reflectance from the earth's surface and by the effects of scattering, which changes depending on the geographic area, the day or season, and the wavelength of the radiation captured by the sensor.

Preprocessing operations to correct for atmospheric degradation fall into three broad categories (Campbell, 1987):

1. ***Models of the physical behaviour of the radiation as it passes through the atmosphere***: They attempt to model the physical process of scattering at the level of individual particles and molecules. They have rigor, accuracy and applicability, but they are too complex to be used in most of the circumnstances, because they require meteorological information (humidity, contentration of gasses, etc.).

2. ***Knowledge of the reflectances of some reference objects***: These methods are based on the comparison of the known reflectance of an object (by field measurements) with the reflectance that appears on the multispectral images. A

simplification of this method, proposed by Chavez (1975), is the correction of the histograms of each band with respect to its minimum value, which is supposed to belong to zero-reflectance areas (i.e., clear water bodies, shadows). Figure 6.1 shows the effect of the Raleigh scattering on the spectral bands of an image, which can be corrected by this method. Table 6.1 and figure 6.2 show an example of its application.

3. ***Interrelationships between the reflectance values of different spectral bands***: One of these procedures is the comparation of the values of visible bands with respect to the NIR band on a scattering plot. The cutting point of the regression line with one of the axes (the visible variable) gives the correction index to be applied.

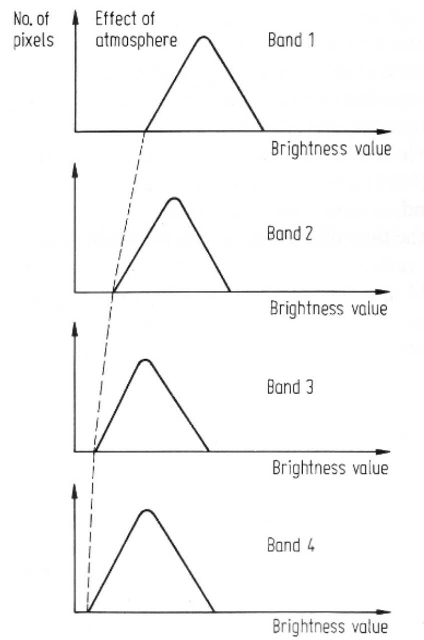

Figure 6.1.- Effect of Raleigh scattering on the histograms of an image Landsat MSS (Schowengerdt, 1997)

<u>Example</u>: Radiometric correction based on subtraction of minimum values of the histogram.

Table 6.1.- Effect of the radiometric correction based on subtraction of minimum values of the histogram

	Before correction		After correction	
Band	**Minimum**	**Maximum**	**Minimum**	**Maximum**
1	44	108	0	64
2	25	96	0	71
3	16	130	0	114
4	17	124	0	107
5	10	164	0	154

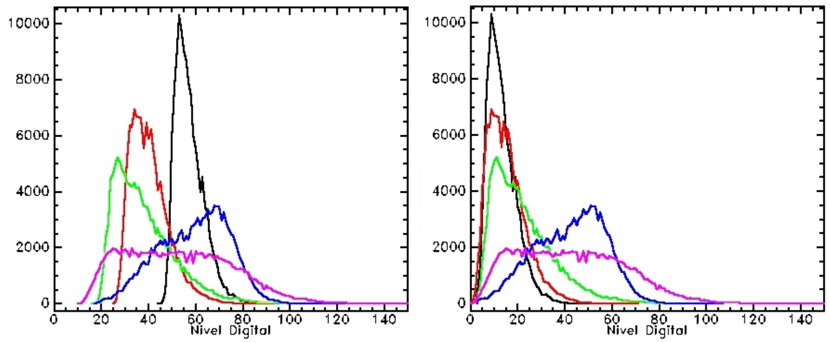

Figure 6.2.- Effect of the radiometric correction of table 6.1 on the histograms of 5 spectral bands

6.2.- Sensor corrections

Some radiometric errors are due to sensor malfunctions or simply by a difference in the calibration of the individual detectors that compose a sensor. The calibration of each detector is controlled by the gain and the offset, and it may be subject to some distortions during the life of a sensor (figure 6.3)

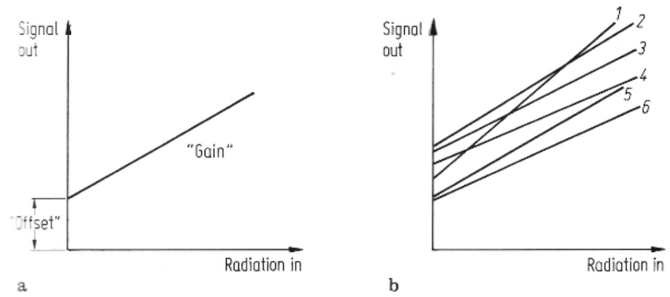

Figure 6.3.- Calibration parameters of a sensor (left), and example of differences on calibration of the 6 detectors from a sensor system (right). (Richards, 1993)

Differences on calibration of single detectors lead to two principal errors: *line dropout* and *striping*.

- ***Striping***: Caused by small differences in the sensitivities or calibration of single array detectors within the sensor. It is typical of whiskbroom sensors, and the resulting image shows a banding horizontal pattern, whose period of repetition is given by the number of detectors that compose the sensor.

- ***Line dropout***: One of the detectors fails to work, so its respective line on the image does not have any value (it is black).

There are two simple <u>ways to correct</u> these radiometric errors:

- <u>Local averaging</u>: Values of the erroneous line are corrected by substituting an average of values of adjacent pixels. This procedure is usually applied for *line dropout* correction.
- <u>Radiometric normalization</u>: Histograms of lines at intervals equal to the number of detectors are examined and parameterized to detect those lines that are brighter or darker than others, and ajusted to correct those that are considered erroneous. This method is usually applied to correct *striping*. (Figure 6.4).

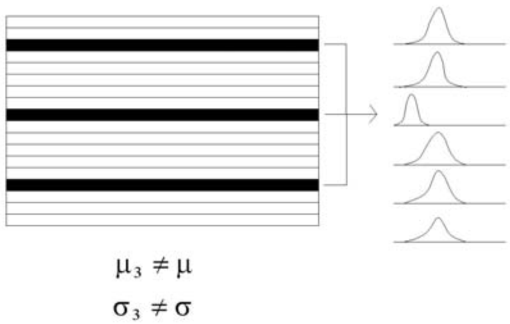

Figure 6.4.- Detection of striping and correction by radiometric normalization

One of the most common and efficient methods of radiometric normalization is based on the calculation of the mean and standard deviation of all the lines corresponding to each detector, and correct the histogram of the lines generated by the erroneous detector using a linear transformation based on the mean and standard deviation of the histograms of the rest of the lines. Here is an example:

Let f(x,y) represent the image of all the lines obtained with the erroneous detector, with μ_f = 100 and σ_f = 10, and g(x,y) the image formed by the rest of the lines of the original image, with μ_g = 80 and σ_g = 15 . Based on these data, define a linear transformation that corrects the image f taking g as the reference.

Transformation: $g = a f + b$

Where $a = \sigma_g / \sigma_f = 15 / 10 = 1,5$; *and* $b = \mu_g - a\,\mu_f = 80 - 1,5 \times 100 = -70$

Resulting transformation <u>$g = 1,5 f - 70$</u>