

MODULE – 3 LECTURE NOTES – 3

ATMOSPHERIC CORRECTIONS

1. Introduction

The energy registered by the sensor will not be exactly equal to that emitted or reflected from the terrain surface due to radiometric and geometric errors. They represent the commonly encountered error that alters the original data by including errors. Of these, geometric error types and their methods of correction have been discussed in the previous lecture. Radiometric errors can be sensor driven or due to atmospheric attenuation. Before analysis of remote sensing images, it is essential that these error types are identified and removed to avoid error propagation.

2. Sensor driven errors

Such errors occur due to the improper functioning of the sensor system. Some of the commonly encountered error due to sensor malfunctioning are discussed below:

- a. **Line drop out** : This error results in transverse scanning systems when out of the multiple detectors used, 1 or 2 fails to function properly. Satellites like Landsat MSS has 6 detectors of which sometimes even if one detector fails to function properly, this results in zero DN recorded for every pixel during corresponding scan lines. Such images will be smeared with black lines.

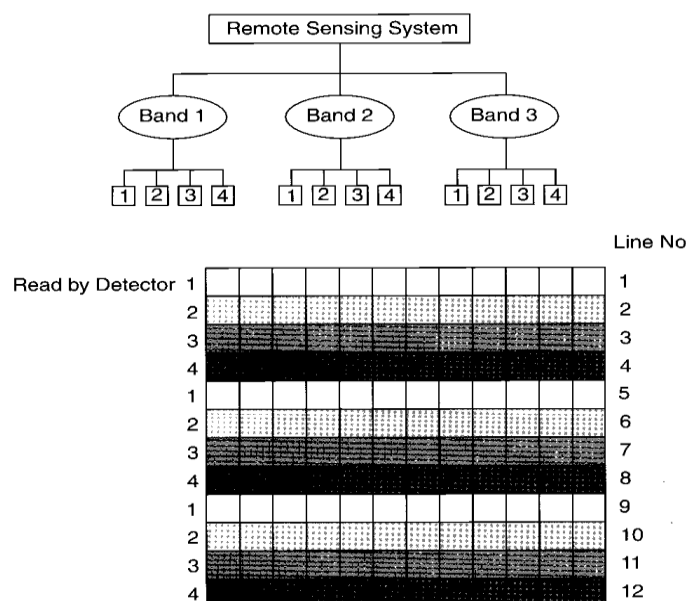


Figure 1: Sequence of lines read by detectors in Transverse scanning system

There is no exact methodology to restore the DN values of such images. However, to improve the interpretability of such images, sometimes average of preceding and succeeding lines of DN are used as corrected DN values. The justification of this procedure stems from the geographical continuity of terrain.

b. **Line banding:** Some detectors generate noise which is a function of the relative gain/offset differences of the detectors within a band which results in banding. Such errors can be corrected using a histogram based approach. For example, a histogram for each detector in each band can be produced. Assuming that each detector has sensed a representative sample of all the surface classes within the scene, each of the histograms will be similar (i.e., have the same mean and standard deviation) if the detectors are matched and calibrated. However, even if one detector is no longer producing data readings consistent with the other detectors, its histogram will be different. An average histogram can be generated by using the DN values from all the detectors except the faulty detector. The DN produced by all the detectors get altered so that their histograms are then made to match the average one. When this procedure is completed, the imbalance between the detectors is eliminated and the image is said to have been de-striped. This procedure changes the DN for all the lines, though the relative change for the properly functioning detectors is less when compared to systems having more detectors. A defective detector on the Landsat MSS forms one-sixth of the input to the average histogram whereas a defective detector for a reflected TM band contributed only one –sixteenth of the input to the average histogram. Fig. 2 show the histograms of each detector that tries to visually depict the line banding effect in detector 4. Fig. 3 shows the corrected histogram for the faulty detector 4.

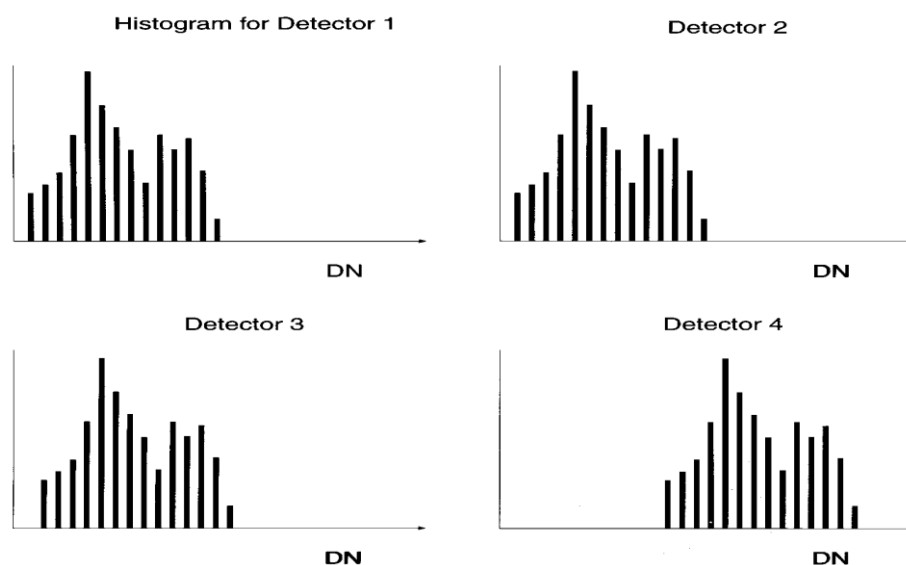


Figure 2: Histogram of each detector of a hypothetical band

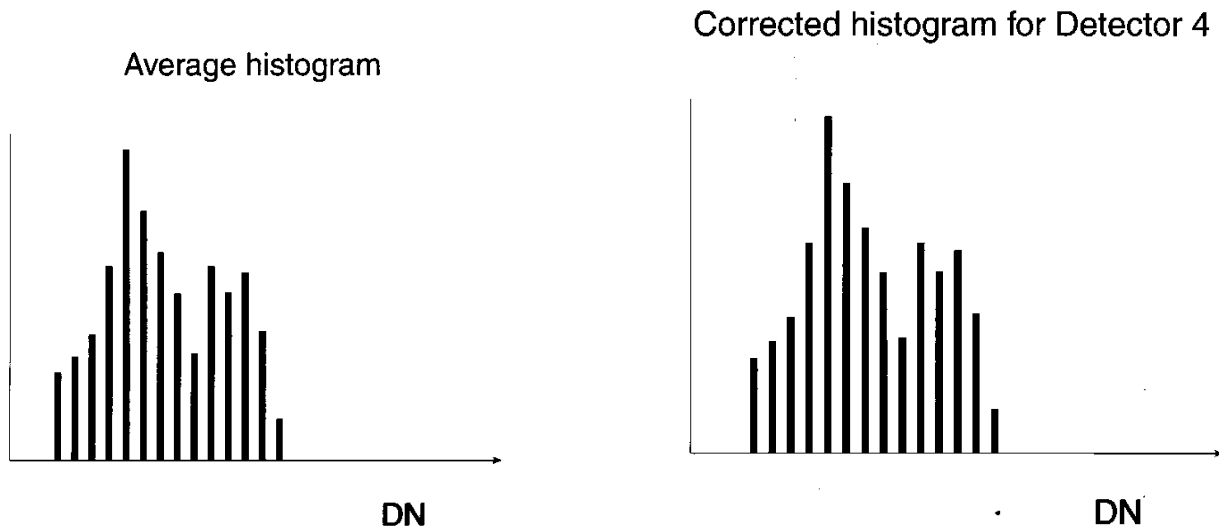


Figure 3: Line banding corrections

3. Atmospheric Corrections

The DN measured or registered by a sensor is composed of two components. One is the actual radiance of the pixel which we wish to record, another is the atmospheric component. The magnitude of radiance leaving ground is attenuated by atmospheric absorption and the directional properties are altered due to scattering. Other sources of errors are due to the varying illumination geometry dependent on sun's azimuth and elevation angles, ground terrain. As the atmosphere properties vary from time to time, it becomes highly essential to correct the radiance values for atmospheric effects. But due to the highly dynamic and complex atmospheric system, it is practically not possible to understand fully the interactions between atmospheric system and electromagnetic radiation. Fig. 4 shows schematically the DN measured by a remote sensing sensor. However, the relationship between received sensor radiance and radiance leaving ground can be summarized in the form of the following relation:

$$L_s = T * \rho * D + L_p$$

Where, D is the total downwelling radiance, ρ is the target reflectance, T is the atmospheric transmittance. The atmospheric path radiance and radiance leaving ground is given by L_p and L_s . The second term represents scattered path radiance, which introduces “haze” in the imagery.

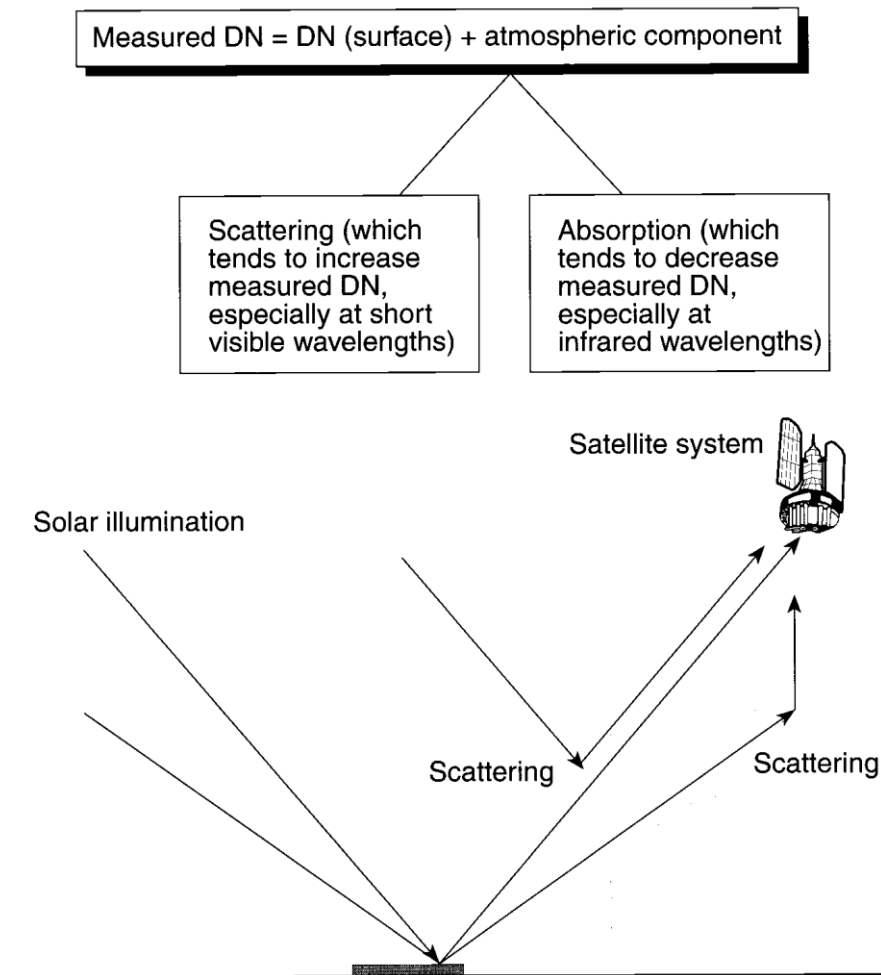


Figure 4: Atmospheric correction to DN measured by remote sensing sensors

The means of correcting for atmospheric attenuation are discussed below:

a. Based on images

Some of the simple techniques used are based on the histogram minimum method and regression. The extent to which the atmosphere alters the true DN is best seen by examining the DN histograms for various bands. Many scenes contain very dark pixels (such as those in deep shadow) and it might be assumed that they should have a DN of zero. A first order atmospheric correction may be applied to remotely sensed datasets by assuming that the offsets are due solely to the atmospheric effects and by subtracting the offset from each DN.

Regression method is applied by plotting pixel values of say near infra red (NIR) band with respect to values of other bands. Then a best fit line is fitted to represent the relationship, wherein the offset/intercept represents an estimate of the atmospheric path radiance.

b. Radiative transfer model

There are several numerical radiative transfer models available such as LOWTRAN, ATREM 5S/6S etc which make use of different assumptions to model the complex and dynamic atmosphere system. The use of these models requires huge amounts of data collection. Sometimes, due to the associated high costs for data collection, the use of standard atmospheres such as mid latitude summer is relied upon.

c. Empirical method

This method relies on apriori knowledge about the reflectance of two targets-one of which is light and the other is dark. Now, the radiances recorded by the sensor can be calculated from the DN of images. The line joining the two target points can be defined to determine the intercept representing atmospheric radiance.

Though the above methods are available to rectify errors due to atmospheric attenuation of radiance energy flux, several studies have relied on avoiding this step suggesting that when the training data and the data to be classified are both measured on the same relative scale, the atmospheric attenuation from both sources tend to cancel out.

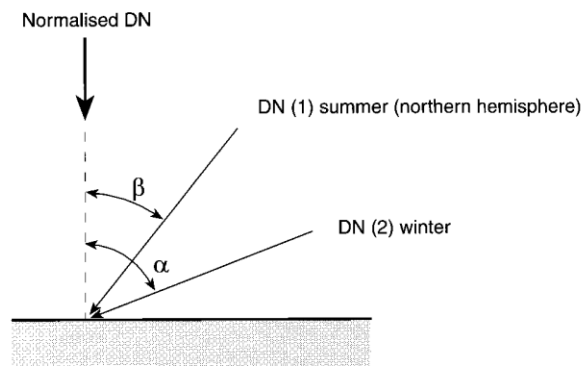
4. Solar Illumination Corrections

Satellite sensor recorded radiance is dependent on several factors such as the reflectance properties of the target, view angle of sensor, solar elevation angle, terrain surface characteristics like slope aspect etc, and on atmospheric attenuations. As shown in Fig. 5, corrections need to be applied to DN in order to take an account of different illumination angles. The reflectance of any target varies with change in illumination angle and angle of view of sensor. A function called as bi-directional reflectance distribution function (BRDF) is the name given to the function relating magnitude of upwelling radiance of target with respect to these two angles. Images obtained at different times of the year are acquired under different illumination conditions. Solar illumination angle, as measure from the horizontal, is greater in the summer than in the winter.

As the earth's surface is not flat, terrain slope and aspect properties introduce radiometric distortion. Among the different means of correcting terrain effects, one of them namely the cosine correction is discussed. Assuming a lambertian surface, a constant distance between

Earth and sun and a constant amount of solar energy illuminating earth, the magnitude of irradiance that reaches a pizel on a slope is going to be directly proportional to the cosine of the incidence angle. This can be written as:

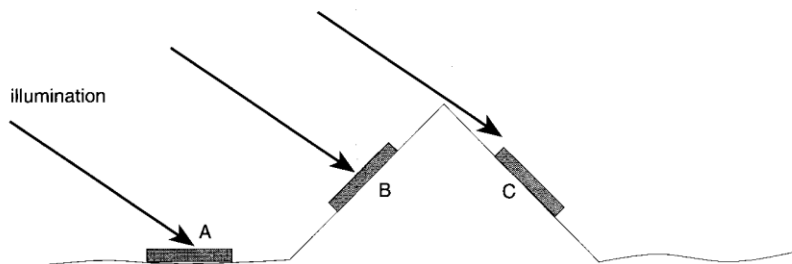
$$L_H = L_T \frac{\cos \theta_0}{\cos i}$$



$$\text{Normalised DN (1)} = \frac{\text{DN (1)}}{\cos \beta}$$

$$\text{Normalised DN (2)} = \frac{\text{DN (2)}}{\cos \alpha}$$

a



reflectance properties of A = reflectance properties of B = reflectance properties of C

illumination of A \neq illumination of B \neq illumination of C

radiance (A) \neq radiance (B) \neq radiance (C)

\therefore DN (A) \neq DN (B) \neq DN (C)

b

Figure 5: (a) Correction applies to measured DN in order to take account of different illumination angles (b) Effect of varying aspect with respect to illumination on the measured DN.

Bibliography

1. Paul. MK. Mather, 2004, Computer Processing of Remotely- Sensed Images, Wiley & Sons.
2. Lillesand T. M. & Kiefer R. W., 2000. *Remote Sensing and Image Interpretation*, 4th ed. Wiley & Sons.
3. John R. Jensen, 1996, Introductory Digital Image Processing, Prentice Hall