

LAB EXERCISE NO. 06
Total Points: 5

DUE DATE: 10/08/2015

TOPIC: BI-DIRECTIONAL CORRECTIONS OF SATELLITE IMAGES

As we discussed in class, bi-directional effect on satellite images due to difference in sun-target-sensor geometry can be significant and therefore it is critical to reduce the effect to a minimal degree when analyzing the data. Many BRDF models have been developed over the past decades and they can be used to normalize bi-directional effects if we know the model parameters. In this lab exercise, you are asked to build a model to do so in ERDAS environment. In particular, we will use a BRDF model developed by Roujean *et al* (1992) to normalize bi-directional effect of both ETM and Vegetation images. These images will be provided to you in the lab. You need to know the terms in the model (described below).

$$\rho(\theta_s, \theta_v, \varphi) = k_0 + k_1 f_1(\theta_s, \theta_v, \varphi) + k_2 f_2(\theta_s, \theta_v, \varphi)$$

$$f_1(\theta_s, \theta_v, \varphi) = \frac{1}{2\pi} ((\pi - \varphi) \cos \varphi + \sin \varphi) \tan \theta_s \theta_v - \frac{\tan \theta_s + \tan \theta_v + G}{\pi}$$

$$f_2(\theta_s, \theta_v, \varphi) = \frac{4}{3\pi} \frac{1}{\cos \theta_s + \cos \theta_v} \left(\left(\frac{\pi}{2} - \xi \right) \cos \xi + \sin \xi \right) - \frac{1}{3}$$

$$G = \sqrt{\tan^2 \theta_s + \tan^2 \theta_v - 2 \tan \theta_s \theta_v \cos \varphi}$$

$$\cos \xi = (\cos \theta_s \cos \theta_v + \sin \theta_s \sin \theta_v \cos \varphi)$$

Example values of k0, k1 and, k2 are provided below. It should be noted that the coefficients are not universal, i.e., you cannot apply them for all biomes. This set of model coefficients is for exercise purpose only. This table contains coefficients for TM spectral bands. For vegetation, you can choose corresponding spectral bands from table for exercise purpose only.

	B1	B2	B3	B4	B5	B7
k0	0.0132	0.0322	0.0211	0.3809	0.1847	0.1847
k1	-0.0085	-0.0096	-0.009	-0.0565	-0.0318	-0.0318
k2	0.0789	0.137	0.0948	0.8118	0.5342	0.5342

Procedure

Since the major purpose of this exercise is how to learn HOW to make bi-directional corrections, you are asked to make a model for ONE single spectral band only (either band 3 or 4 or do both if you want to). If you want to build a model that can correct all spectral bands, you are welcome to. In the following procedure, you can choose any spectral band from your input file.

1. Open a spatial model window in ERDAS 2014.
2. Place an input file.
3. Place three data input matrices (single squares on the tool manual) for constants k_0 , k_1 , and k_2 .
4. Place another four matrix inputs for solar zenith, solar azimuth, view zenith, and view azimuth angles. These will be your “standard” sun-earth-sensor viewing geometry information.
5. Compute relative azimuth angle, φ or “phi” (from the image or provide the information (the difference between the view azimuth and solar azimuth angles).
NOTE: when you use this model, the relative azimuth angle ranges from 0 to 360 degrees while the other models require this range to be from 0 to +/- 180 degrees.
6. Compute G .
7. Compute ξ or “Xi”
8. Compute coefficients f_1 and f_2 .
9. Compute $M = k_0 + k_1 * f_1 + k_2 * f_2$.
This is to compute the modeled reflectance values using the “actual” sun-earth-sensor viewing geometry. For ETM+ image, you can assume the view angle is nadir. For more accurate result, you should compute view angles for each pixel. How would you do this? For VEGETATION image, the viewing geometry information is provided in separate layers of the image itself.
10. Compute $M_s = k_0 + k_1 * f_1 + k_2 * f_2$
This is to compute the modeled reflectance values using the “standard” sun-earth-sensor viewing geometry, the solar and view angle that you want to normalize your image to.
11. Compute the normalization coefficient $C = M_s / M$
12. Build a function to limit the correction coefficients to be greater than 0.8 and less than 1.2. This is to make sure that you do not have your images ‘overly’ corrected.
13. Time the channel (band) by normalization coefficient C .
14. Repeat Steps 5-13 for each spectral band
15. Run the model to see if they come out the way you expected.

Questions:

1. Are there any changes in your image statistical information such as histograms, mean, min, max, and std, information from metadata window of ERDAS IMAGINE 2014 before and after BRDF corrections with the Landsat image?

Min (before) = _____, Min (after) = _____ (band 1)
Min (before) = _____, Min (after) = _____ (band 2)
Min (before) = _____, Min (after) = _____ (band 3)
Min (before) = _____, Min (after) = _____ (band 4)
Min (before) = _____, Min (after) = _____ (band 5)
Min (before) = _____, Min (after) = _____ (band 7)

Mean (before) = _____, Mean (after) = _____ (band 1)
Mean (before) = _____, Mean (after) = _____ (band 2)
Mean (before) = _____, Mean (after) = _____ (band 3)
Mean (before) = _____, Mean (after) = _____ (band 4)
Mean (before) = _____, Mean (after) = _____ (band 5)
Mean (before) = _____, Mean (after) = _____ (band 7)

Max (before) = _____, Max (after) = _____ (band 1)
Max (before) = _____, Max (after) = _____ (band 2)
Max (before) = _____, Max (after) = _____ (band 3)
Max (before) = _____, Max (after) = _____ (band 4)
Max (before) = _____, Max (after) = _____ (band 5)
Max (before) = _____, Max (after) = _____ (band 7)

2. Provide two examples of a spatial profile of your choice on both the original and corrected VEGETATION image. Try to draw your spatial profile across the strip you see on the image. Is there any difference between the two profiles? Use the bi-directional property terms we learnt in ass to explain the differences, or explain why there is no difference.
3. Discuss at least three potential problems of using a single BRDF model with a single set of model coefficients for the entire image.