LAB EXERCISE NO. 03   **DUE DATE: 9/24/2015**
Total Points: 5

TOPIC: Atmospheric corrections of Satellite Images- ERDAS 2014

Instructions: In the previous lab exercises, you have computed per-pixel TOA reflectance values from an L5 image. Although the TOA reflectance closely represents surface optical properties, it is not the true surface reflectance. There is need to minimize or remove atmospheric effect. In addition to the atmospheric effect, we also need to correct bi-directional effect due to non-Lambertian properties of natural surfaces. In the next two exercises, you will have the chance to do both atmospheric and bidirectional corrections. You will use two methods to correct atmospheric effect

Method One – Dark Object Subtraction

This technique assumes that the radiance reflected off a "dark" surface should be zero. Therefore, the reflectance values of these dark objects are assumed to be zero too. By subtracting the values of these dark objects from the TOA image one can convert TOA reflectance to "surface" reflectance values.

Procedures:
1. Open the TOA image you used from the last lab exercise in ERDAS IMAGINE viewer.
2. Find the dark objects you think can be used in atmospheric correction as dark objects.
3. Draw an area of interest (AOI) and re-compute the statistics using the AOI you just drew
4. AOI creation: File/new/2D view/ AOI layer; click on "AOI/drawing tab" and then search for tools from various operations under "insert geometry" to create your AOI. Then, Save as / Save AOI as "filename".
5. File -> New -> 2D View -> AOI Layer
6. 2)   Draw -> polygon (for an dark object)
7. 3)   Raster -> Supervised -> Signature Editor -> +L -> View -> Statistics (note, please selected the polygon first)
8. Write down the mean values of the new stats for each band in table 1 below:

Table 1. Fill in the table with the mean value of the dark objects found in the image

Dark objects	TM1	TM2	TM3	TM4	TM5	TM 6	TM7

9. Build a new spatial model and specify a function so that the values from table 1 are subtracted. Save this model with a file name as DOS and add it to your model (.gmd) folder.

10. Run the model and compute the "surface" reflectance values. Name the output file as something that reflects the DOS technique, which later will be compared with the radiative transfer method.

Method Two – Radiative transfer model

This technique is to use a model, often built with in-atmospheric profiles, to compute the attenuation of the solar radiation, and therefore the attenuation if the surface reflected radiation or radiance. As demonstrated in the class, you will have to select one of the built in models to compute your atmospheric effect (attenuation). In theory this has to be done virtually for very pixel on the image, which is time consuming. One commonly used technique is to compute the TOA reflectance from a set of surface reflectances and then establish a linear relationship between TOA reflectance and the input surface reflectance image. Doing so, one can save tremendous computation time. We will use this approach in this exercise. Procedures:

These procedures have to be done on two platforms: your own PC and UNIX or Solaris systems.

On your PCs (laptops or try desktops)

1. Go to http://6s.ltdri.org/pages/run6SV.html. Click on submit query.
2. The following is displayed:

Make your own atmospheric correction

The 6s code predicts the satellite signal from 0.25 to 4.0 microns assuming cloudless atmosphere. The main atmospheric effects (gaseous absorption by water vapor,carbon dioxyde,oxygen and ozone; scattering by molecules and aerosols) are taken into account. Non-uniform surfaces may be considered,as well as bidirectional reflectances as boundary conditions. The following input parameters are needed

Geometrical conditions

Atmospherical Model

Target & Sensor Altitude

Spectral Conditions

Ground Reflectance

Signal

Results

At each step, you can either select some proposed standard conditions (for example, spectral bands of satellite for spectral conditions) or define your own conditions (in the example, you have to define the assumed spectral response).

3. Under "Geometric", select "TM". Enter the experiment longitude and latitude as the coordinates of the scene center. Latitude must be > 0 for north lat., < 0 for south lat. Longitude must be > 0 for east long., <0 for west long. Find and enter information (month, day, lat, long, of scene center, and GMT or Zulu time of acquisition) using .MTL file. To obtain scene center pixel, add Landsat image to viewer, zoom to extent, and click 'enquire cursor" and select "lat/lon WGS 84 under "map".

4. 4. In the next step, enter information for the module, namely "Atmospheric model". Select atmospheric profile, for e.g., mid-latitude summer or tropical; and aerosol model, for e.g., continental, urban depending on the scene. For continental model, enter 20km for visibility.

5. For "Target and Sensor altitude", select target altitude from sea level and sensor altitude in Km (find out Landsat 5, 7 or 8 orbit altitude).

6. Under "Spectral Conditions", choose "band" and select bands for specific Sensor. In our case this would be Landsat 5 (bands 1,2,3,4,5,7).

7. Specify "Ground reflectance" by picking either homogenous surface or non-uniform surface as well as directional effect or no-directional effect.

8. Under, "Signal", pick "atmospheric correction mode" , either "atmospheric correction with Lambertian assumption" or "atmospheric correction with BRDF" enter reflectance (apparent) 0., 0.1

9. Run program, View results and add them to the table 1 provided. This will execute online 6sv program with your input file and will generate an output file that correspond to TM bands.

10. Open output files and find the following information:

a. Apparent radiance at the sensor

b. Apparent reflectance at the sensor

c. Fill in table 1.

11. Repeat steps for surface reflectance values of 0.1, 0.2, 0.3, 0.4, 0.5, 0,6, 0.7,0.8, 0.9 and fill in table 1.

12. Use the values you obtained in table 2 to plot, a) surface reflectance vs apparent reflectance at the sensor and b) surface reflectance vs apparent radiance at the sensor.

13. Do a linear regression using the two plots you did in step 7 and fin the slope & intercept for each bands and provide them in table 3 for each spectral band. You are asked to bring a copy of your coefficients to the lab and build a spatial; model in Erdas Imagine.

On Lab desktops

14. From Step 8, you have obtained atmospheric correction coefficients and you also have built a spatial model from the previous lab exercises (your TOA model). Open your TOA model in model builder and change the output to a temporary file.

15. Then insert a function that computes the surface reflectance from TOA reflectance using the equation you have obtained from step 8. (NOTE: When you place the equations, remember that your input file was scaled by a factor of 255.0. If this is the case you need to divide the TOA reflectance by this factor first in order to correctly use your regression equation.

$$\rho_{surface} = slope * \rho_{TOA} + intercept$$

16. Remember you have to do this for each band. Also name the output file with something that reflects the radiative transfer modelling ("_6s", etc).

17. Run the model to compute the surface reflectance values.

Table 2: To be filled out in Excel using results of 6s model

Input reflectance	Apparent reflectance						Apparent radiance					
0	0.1	0.2	0.3	0.4	0.5	0.6	0.1	0.2	0.3	0.4	0.5	0.6
0.1												
0.2												
03												
0.4												
0.5												
0.6												
0.7												
0.8												

Table 3: Regression parameters from the results of table 1

Bands	Slope		Intercept		Rsquared	
	TOA Ref.	TOA Rad.	TOA Ref.	TOA Rad.	TOA Ref.	TOA Rad.
TM1						
TM2						
TM3						
TM4						
TM5						
TM7						

Note: also try out Py for 6s (https://py6s.readthedocs.org/en/latest/index.html)

Appendix:

Input file for 6S:

```
7 (TM)
6 17 16.03 -84.80207889 43.19147111 (Geometrical conditions)
2 Midlatitude Summer
1 Continental Model
23 visibility or aot
0 (target level)
-1000 (sensor level) (try -705 instead)
25 (chosen band)
0 Homogeneous surface
0 No directional effects
0 constant value for ro
0.1
0 Atm. correction Lambertian
-0.1 reflectance (negative value)
```