

GEOG661
Laboratory Exercise 3

Digital Image Processing
Radiometric Preprocessing and
Atmospheric Correction

Introduction

In this lab you will atmospherically correct a Landsat Thematic Mapper image using correction techniques of varying sophistication. You will be asked to evaluate the effects of the different corrections on the spectral signature on different land cover types.

Satellite Image

On website you will find a portion of a recent Landsat 7 scene covering portion the Bryan-College Station area. In addition, the metadata for the full scene is provided. Pertinent information about the image includes:

- Path: 26
- Row: 39
- Acquisition Date: January 12, 2010
- Solar Zenith Angle: 57.7368965° (the solar elevation is 32.2631035°)
- Earth-Sun Distance: 0.9835 Astronomical Units – as determined from the IDL SUN routine created by Johns Hopkins University/Applied Physics Laboratory

Hint: To view the image in ENVI, load bands 5 4 and 2 as Red, Green, and Blue, respectively. This will create a false-color composite image with easy to interpret colors.

Exercise 1 Create spectral signatures (wavelength versus DN) for a pixel on the non-vegetated Lot 51 parking lot (pixel location 489, 535) and the vegetated Polo Field at (pixel location 494, 540). This can be accomplished using the **Z Profile (Spectrum)** tool to obtain a spectral signature of the two sites. Multiple profiles can be collected using the Collect Spectra Function and then saved as ASCII data or plotted. You will need to examine the actual values later, so you may wish to do more than simply make a plot.

Hint. You may simply wish to record the DN/Radiance/Reflectance for each band of the two targets as well as the wavelength of each band and create the plots in a graphing program. One of the points of the lab is to compare how these spectral profiles change as you move from original DN values to radiances to atmospherically-corrected reflectances so constructing easily comparable graphs will benefit you in the end. You will need these values to computing the NDVI at each step as well.

Exercise 2 Calculate the Normalized Difference Vegetation Index for both of the targets. For Landsat TM, the normalized difference index is calculated as

$$NDVI = \frac{(band4 - band3)}{(band4 + band3)}$$

For the remainder of the lab we will see how both the profiles change and how the NDVI changes as we perform radiometric preprocessing

1. Conversion from DN to Radiance

The first step in radiometric preprocessing is converting the DN values in the original image to at-satellite radiance. The exact procedure for accomplishing this varies between satellites and data providers. For Landsat the procedure to convert from DN to radiance is well-documented in the *Landsat Science Data Users Handbook* in chapter 11. (http://landsathandbook.gsfc.nasa.gov/data_prod/prog_sect11_3.html). The information concerning the scaling for this particular scene can be found in the metadata file provided with the image chip you received. It is good practice to be able to undertake this scaling so I will leave it up to you to follow the procedure described in the Handbook.

Exercise 3 Compute the Gain and offsets needed to convert the DN Value (QCAL in the Handbook) to spectral radiance at the satellite (L_λ in the Handbook) for the six Landsat Bands. Please provide a table of these gains and offsets. Please show your work for Landsat Band 1

Once you have computed the gains and offsets, please apply them to the image to create a radiance image which you will use in later steps.

Hint. In ENVI this is accomplished using the **Apply Gain and Offset Tool** which is found under **Basic Tools** → **Preprocessing** → **General Purpose Utilities** or by performing **Band Math**.

Exercise 4 Once you have successfully converted from DN to Spectral Radiance, recreate your spectral plots for the vegetated and non-vegetated pixels and recompute the NDVI for each target. Discuss how the plots and NDVI have changed.

2. Conversion from Radiance to In-band Planetary Albedo or Reflectance

The next step in radiometric preprocessing is often to convert from radiance to reflectance. A simple approach which does not take into account atmospheric effects, but does normalize for variations in solar irradiance is often useful in reducing variability between images by converting spectral radiance to planetary reflectance or albedo. This procedure is also outlined in the *Landsat 7 Science Data Users Handbook*, but the same general approach can be used for other sensors operating in the optical range.

Exercise 5 Compute the Gain needed to convert the spectral radiance to in-band planetary albedo for the seven Landsat Bands. Please provide a table of these gains. Please show your work for Landsat Band 1

Once you have determined the gain necessary for each Landsat band, please apply them to each of the six bands in the image in them in a manner similar to that in Exercise 3.

Exercise 6 Once you have successfully converted from spectral radiance to in-band planetary albedo, recreate your spectral plots for the vegetated and non-vegetated pixels and recompute the NDVI for each target. Discuss how the plots and NDVI have changed.

3. Relative Radiometric Correction

The first type of correction you need to perform will be a relative radiometric correction. In this lab, you will perform the simplest type – termed a single-image normalization using histogram adjustment by Jensen (2005). It and other relative radiometric corrections are described in Jensen (2005) beginning on page 213.

Exercise 7 Determine the first order scattering or haze correction for each of the six Landsat Bands for the reflectance image you created previously. Complete a table showing the bias correction you have selected to minimize the effects of haze. Please discuss in one or two paragraphs how you determined your bias correction.

Hint. Determining the first order scattering or haze will require computing the statistics and histograms for each band. In ENVI, this is easily accomplished using the **Compute Statistics Tool** found under Basic Tools → Statistics.

Once you have determined the bias necessary to correct for haze in each Landsat band, please apply them to each of the six bands in the image in them in a manner similar to that in Exercise 3.

Hint. In ENVI this is accomplished using the **Dark Subtract Tool** which is found under Basic Tools → Preprocessing → General Purpose Utilities or you can use **Band Math**

Exercise 8 Once you have successfully performed a simple relative radiometric correction, recreate your spectral plots for the vegetated and non-vegetated pixels and recomputed the NDVI for each target. Discuss how the plots and NDVI have changed.

In some instances, determining the biases for a haze correction from the image histograms is not possible or desirable. Instead it may be preferable to use an alternative method to select the values to perform a bias correction. This is to select an area where you know the reflectance will be low (e.g. a clear lake) or heavily shadowed area and use these values to perform a relative atmospheric correction. You can use a single pixel from one of these areas or a mean from a 3x3 or other extended neighborhood.

Hint. In ENVI it is possible to compute use the **Z Profile (Spectrum) tool** to get spectra averaged over a window. To do so use the *Set Z Profile Average function* which is located under Options in the Spectral Profile Tool.

Exercise 9 Determine the bias correction for each Landsat band using this alternative method, again providing them in tabular form. Please describe in one to two paragraphs what object you selected for this correction and what averaging window (if any) was employed.

Once you have determined the bias necessary to correct for haze in each Landsat band, please apply them to each of the six bands in the image in them in a manner similar to that in Exercise 3.

Exercise 10 Once you have successfully performed the alternative simple relative radiometric correction, recreate your spectral plots for the vegetated and non-vegetated pixels and recompute the NDVI for each target. Discuss how the plots and NDVI have changed (if at all) from your previous calculations.