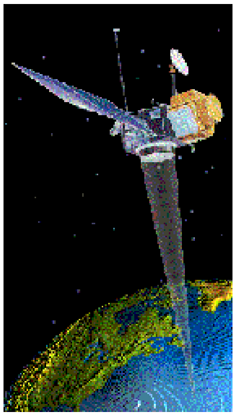

GEOG 472: Remote Sensing: Digital Image Processing and Analysis

Lab #6

Radiance and Reflectance Calibration

Today's lab involves converting the DN values of the College Park TM image into radiance and reflectance values. You will need to use the metadata information included with this image in order to convert the data to reflectance values. Digital sensors record the intensity of electromagnetic radiation from each spot viewed on the Earth's surface as a digital number (DN) for each spectral band. The exact range of DN that a sensor utilizes depends on its radiometric resolution. For example, a sensor such as Landsat TM measures radiation on a 0-255 scale.

Radiance

The unit of electromagnetic radiation is the rate of transfer of energy (Watt, W) recorded at a sensor, per square meter on the ground, for one steradian (three dimensional angle from a point on Earth's surface to the sensor), per unit wavelength being measured. Radiance is a measure of radiant intensity per unit of projected source area in a specified direction. The term exitance is a measure of the amount of radiant flux leaving the Earth (i.e. upwelling, toward the sensor). A different term, irradiance, is used to describe downwelling radiation reaching the Earth from the sun.

Reflectance

Reflectance represents the ratio of exitance to irradiance, and thus provides a standardized measure which is directly comparable between images. Reflectance is unitless and thus is measured on a scale from 0 to 1 (or 0-100%). Top-of-atmosphere (TOA) reflectance does not attempt to account for atmospheric interference. Surface reflectance attempts to atmospherically correct while also converting to reflectance. For this lab, we will calculate the TOA reflectance values.

Conversion of DN to Spectral Radiance

First, we will convert the DN values to radiance, which is converting the digital number recorded by the sensor back to the actual energy units that the digital number represents. This process required information on the gain and bias of the sensor in each band. The transformation is based on a calibration curve of DN to radiance which has been calculated by the operators of the satellite system. The calibration to radiance for each band is given by the following:

$$Radiance\lambda = Bias\lambda + (Gain\lambda \times DN\lambda)$$

where λ = ETM/TM band number.

The gain and bias values for each band are calculated from the lower (Lmin) and upper (Lmax) limits of the post-calibration spectral radiance range. The values of Lmin and Lmax for Landsat TM data can be obtained from the header file we used previously named L71015033_03320020618_MTL.txt

You can calculate the gain from Lmin Lmax with this equation:

$$Gain = (Lmax - Lmin)/255$$

1) Calculate and record the gain values for Band 3 and Band 4.

2) Define sensor gain and bias.

Converting DN values to Spectral Radiance and Reflectance

The formula for at-satellite reflectance values is as follows:

where:

λ	=	ETM+/TM band number
L	=	at-satellite radiance
gain	=	band specific, provided in the header file sceneid.h1
bias	=	band specific, provided in the header file sceneid.h1
ρ	=	at-satellite reflectance, unitless
d	=	Earth-Sun distance in astronomical unit
ESUN	=	Mean solar exoatmospheric irradiance from Table 1
θ	=	Sun elevation angle, provided in the header file sceneid.h1

Luckily, you can easily convert Landsat TM data to radiance and reflectance values in ENVI.

To calculate radiance and reflectance values, you will need to use the full scene TM images for Band 1 and Band 3. These images are located on the U:Instruction drive in the 472/spr07 folder under lab_6images

Calculate the reflectance values for Band 1 and Band 3. You will find this function under Basic Tools/Preprocessing/Calibration Utilities/Landsat TM. Compare the default information that comes up with your image metadata file to make sure that it is correct (this is the same metadata file that we used previously). You will need to enter values for the sun elevation and minimum and maximum values, (Lmin and Lmax) which you can find in the image header file. Calculate both reflectance and radiance images and examine your results. You will use the results to answer questions 6-8.

3) When and why is image radiometric correction necessary?

4) What information do you need to convert radiance values to reflectance?

5) In what image processing circumstances is it not necessary to convert DN values to reflectance values?

Relative Atmospheric Adjustment

Comparison of Reflectance Bands:

Absolute radiometric correction requires sensor calibration coefficients and an atmospheric correction algorithm usually based on radiative transfer code. Unfortunately, the application of these codes to a specific scene and date also requires knowledge of both the sensor spectral profile and the atmospheric properties at the time of remote sensor data collection (Du et al., 2002). If all this information is available, then it is possible for the atmospheric radiative transfer code to provide realistic estimates of the effects of atmospheric scattering and absorption and convert the imagery to scaled surface reflectance.

Dark object atmospheric adjustment is a method of correcting for atmospheric scattering. We would assume that deep water bodies would appear black in Band 1 and Band 3. The difference in these bands is due to atmospheric scattering. We can determine what percent reflectance is accounted for by atmospheric scattering and subtract this from our image for relative atmospheric adjustment. Look at the output reflectance value images for Band 1 and Band 3 to answer the following.

6) If you assume that the water has near zero % reflectance, how much reflectance would you have to subtract from the scene in Band 1 to account for atmospheric scattering?

7) What percent reflectance would you have to subtract from Band 3 to account for atmospheric scattering?

8) What information would you need to account for atmospheric scattering and absorption to convert to absolute (rather than relative) reflectance values? What is the visual affect of atmospheric scattering on an image?

As a final step, please delete the full image Band 1 and Band 3 files you have, along with any images you may have created today!

Link to Data File