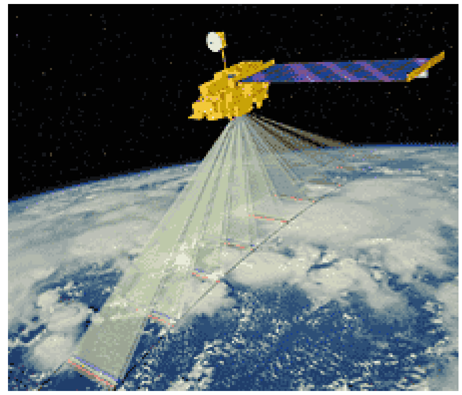
Exercise #1

Measurement and Analysis of Reflectance



Objectives

- **To determine the most useful bands for discriminating different land cover.**
- **To identify features based on spectral reflectance curves.**

As humans, the colors we see are made up of combinations of reflected wavelengths throughout the visible portion of the electromagnetic spectrum. Each feature that we see has its own unique ***spectral reflectance curve*** (i.e. grass, water, cement, etc). These curves are defined by the varying percent of reflectance. The color we see comes from the wavelengths which are reflected the most. For example, a green object will reflect high in the green portion of the spectrum, but low in blue and red. Graphs of spectral reflectance curves help us better understand the reflectance nature of an object.

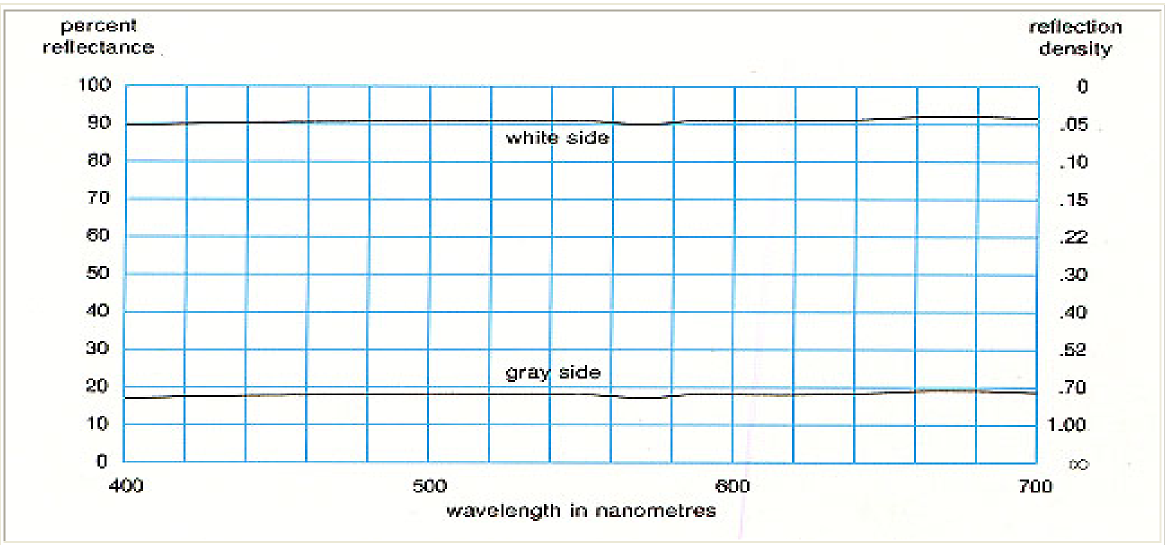
In remote sensing, one must understand the reflectance nature of an object if it is going to be identified on an image. ***In-situ*** or reference data is often collected at the time of image acquisition. One form of reference data is the ground-based measurement of the reflectance of surface features to determine their spectral response patterns. This might be done in the laboratory or in the field using a ***spectroradiometer.*** This device measures, as a function of wavelength, the energy coming from an object within its view. It is used primarily to prepare spectral reflectance curves for various objects.

In this exercise, we will use a multiband ***radiometer*** that measures radiation in a series of discrete spectral bands, rather than over a continuous range. The one we will use operates in four spectral bands (blue, green, red, and near infrared). These bands are similar to the bands used by the Thematic Mapper (TM) sensor onboard the Landsat satellites and the high resolution visible (HRV) sensor onboard the SPOT satellites.

In this exercise, you are to compute radiometric data from previously obtained instrumentation readings and then plot the spectral reflectance curves in graphic format. This will allow you to determine which bands are most useful for discriminating different land cover types. Reflectance curves such as these have already been generated for a large number of surfaces. It is up to you to examine these curves and predict the contrast relationship between various targets. By analysis of experimental results such as these, the scientist may be able to choose the proper spectral band combinations for a given remote sensing task. Theoretically, **the higher the reflectance contrast between any two imaged objects, the easier it should be to distinguish them.** The easier an object is to distinguish, the greater the potential is for fast, accurate image interpretation.

Determining the Most Useful Bands for Target Discrimination

In this exercise you will calculate the spectral reflectance from a variety of land covers. This is the proportion of incoming light that is reflected back out by each land cover type ("target"). The data you need are provided in Table 1 below. You should use the Excel version of this, Table 1, to complete your assignment. The percent target reflectance for each of the four bands (blue, green, red, and near-infrared) can be calculated through steps 1 – 3.



This graph shows the percent reflectance and the reflectance density of a KODAK Gray Card in relation to light wavelength in nanometres.

To find the amount of flux incident (arriving) at the ground we use a gray card whose reflectance throughout the spectrum = 0.18. The radiometer instrument gain is 125. The "instrument gain" is an amplification factor used by a measuring instrument. It is the amount by which the actual signal is multiplied before the result is displayed or output. Then the amount of incident radiant flux (light) is given by:

> Incident Radiant Flux **=** (radiometer gray card reflected flux / radiometer instrument gain) / 0.18

1. What is a gray card? (Find out!)

2. Why do you think we might use a gray card to calculate the incoming flux? (Think about how one might find out the incoming flux - If you were designing an experiment to measure the incident radiation, how would you find this?)

3. Why do we need to divide the measured reflected flux (i.e. the radiometer value) by the instrument gain?

The reflected radiant flux from the **target** (i.e. the amount of light that the ground reflects) is given by:

> Target Reflected Radiant Flux = radiometer target reflected flux / radiometer instrument gain

The **reflectance** of the target is given by:

> Target Reflectance = (target reflected radiant flux / incident radiant flux) x 100

4. Why do we multiply the ratio by 100?

5. Table 1 is shown below. Use Excel to complete this table (Table 1**) and calculate the target reflectance as a percent. Hand in a print out of your completed table. Please format your cells using a fixed number of decimal places or scientific notation as appropriate.**

Landcover	Landsat TM Band	Radiometer Gray Card Reflected Flux	Incident Radiant Flux	Radiometer Target Reflected Flux	Target Reflected Flux	Target Reflectance
	1 BLUE	0.13		0.05		
Green	2 GREEN	0.15		0.10		
Sweetgum	3 RED	0.12		0.05		

	4 NIR	0.17	0.40
	1 BLUE	0.13	0.09
Yellow	2 GREEN	0.15	0.19
Sweetgum	3 RED	0.12	0.19
	4 NIR	0.18	0.32
	1 BLUE	0.13	0.05
Red	2 GREEN	0.15	0.08
Sweetgum	3 RED	0.12	0.15
	4 NIR	0.18	0.30
	1 BLUE	0.13	0.04
Brown	2 GREEN	0.15	0.09
Sweetgum	3 RED	0.12	0.12
	4 NIR	0.18	0.28
	1 BLUE	0.12	0.04
Grass	2 GREEN	0.16	0.08
	3 RED	0.11	0.04
	4 NIR	0.16	0.40
	1 BLUE	0.12	0.10
Concrete	2 GREEN	0.16	0.16
	3 RED	0.11	0.12
	4 NIR	0.16	0.20
	1 BLUE	0.12	0.05
Laterite	2 GREEN	0.16	0.08
Soil	3 RED	0.11	0.07
	4 NIR	0.16	0.15
	1 BLUE	0.28	0.03
Water	2 GREEN	0.3	0.02
	3 RED	0.22	0.01
	4 NIR	0.32	0.01

6. Using Excel, create a graph of spectral reflectance curves for each of the land covers listed in the table. Plot the target reflectance percentages (y-axis) in each of the four bands (x-axis). The x-axis should show band number/color or band wavelength (preferable – You can obtain this for Landsat TM from the text (Chpt 7) or from the web). Use appropriate colors or line patterns to distinguish each of the individual reflectance curves. You should create a single graph showing 8 lines (one for each of the land cover types in the table). Print out and hand in your graph.

Once you have completed the graph, answer the following questions:

7. Determine which of the bands is best for discriminating between the following target classes:

A. Green Sweetgum and Red Sweetgum

B. Yellow Sweetgum and Green Sweetgum

C. Brown Sweetgum and Red Sweetgum

D. Brown Sweetgum and Grass

E. Grass and Soil

F. Concrete and Soil

E. Water and Soil

8. In which of the four bands is Yellow Sweetgum the lightest tone (highest reflectance)? The darkest tone (lowest reflectance)?

9. If you were to choose only two spectral bands to discriminate between all targets, which bands would you select and why?

10. How do you think the presence of moisture in soil will affect its reflectance? Why?

11. What do you think might be some of the factors that affect the reflective nature of water?

Last Modified: 7 Jan 2009 by Helen Cox