Land Remote Sensing
Assignment #3: Basics of image and spectral analysis
**Due: Oct 14, 2015**

Name_____

The files you'll need are at:
http://wray.eas.gatech.edu/remotesensing2013/RS_Lab2_files.zip

Background on spectral continuum

An example of a spectral continuum is shown in Fig. 1. The continuum is not a best fit line! It is a curve that fits "over the top" of the spectrum. Removing the continuum removes the overall curvature of the spectrum, and normalizes it. Recall that absorption bands are the primary features of interest when doing spectroscopy to determine surface compositions. After continuum removal, a part of the spectrum with no absorption will have a value of 1, whereas complete absorption (albeit unlikely to actually occur) would be 0, with most absorptions falling somewhere in between.

The spectral continuum can be thought of as what the original spectrum _would_ look like if there were no absorption band. The continuum-removed spectrum is the original spectrum divided by the continuum. As an example, let's look at the three spectra in Figure 1, each at the 1.91 μm wavelength position. Note that the y-axis of Figure 1 is somewhat mislabeled: the units for the kaolinite spectrum and its counterpart continuum are indeed reflectance, but the continuum-removed spectrum is really unitless since it is a ratio of two spectra. At 1.91 μm, the kaolinite spectrum's reflectance is about 0.43, while the value of the continuum at that wavelength is approximately 0.57. The ratio 0.43/0.57 = 0.75 is the continuum-removed spectrum's approximate value at that wavelength.
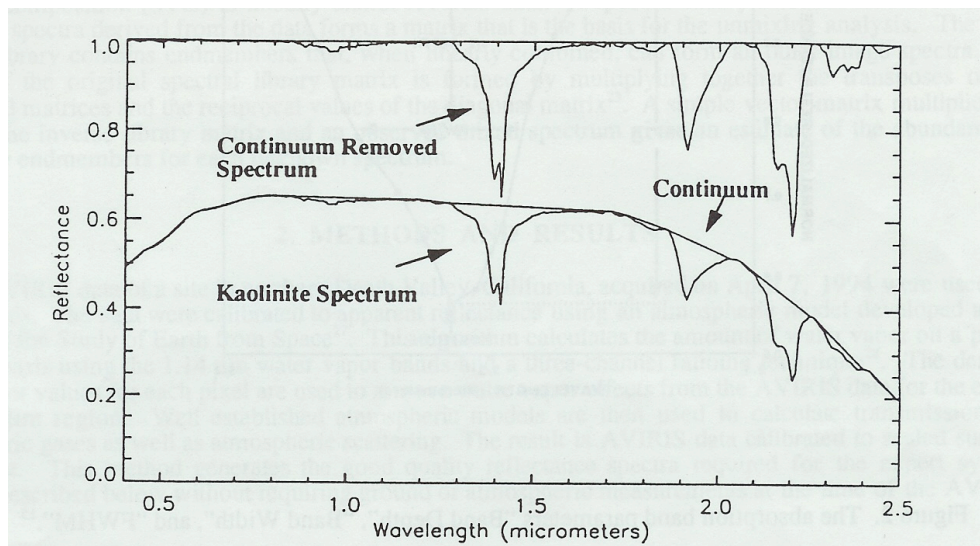

Figure 1. Examples of a kaolinite spectrum, its continuum, and its continuum-removed spectrum.

In practice, the spectral continuum is used for two basic reasons. One, it is sometimes useful for spectral matching routines that require knowledge of the exact

wavelengths where an absorption begins and ends. Since any value less than 1 is an absorption, this becomes easy, except in the case of overlapping absorptions. Some types of spectral analysis are based on analysis of absorption band *shape*. These kinds of analyses are based on measurements of parameters like *band depth, band position*, and the full width of the absorption at half the band depth (*full width half maximum, or simply FWHM*), as illustrated in Figure 2.
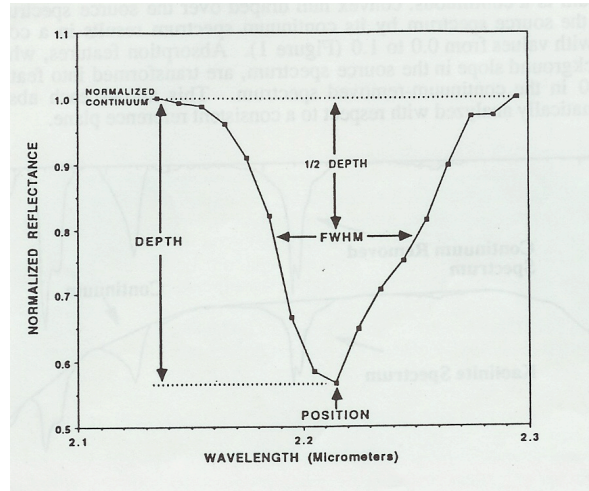

Figure 2. Examples of absorption features that can be measured on continuum-removed spectra.

Recall that a spectrum is an array of numbers that represents some property sampled at different wavelengths of the electromagnetic spectrum. Because there are many such properties that can be used (e.g., reflectance, emissivity, or radiance), there are many different kinds of spectra with different units. However, all of these spectra have the same shape (with the exception of emissivity spectra, which are "inverted" relative to reflectance). This represents the second common use of continuum-removed spectra. If you have, for example, an image cube of radiance spectra, but a spectral library of spectra scaled to percent reflectance, and you do not have a way to convert between the two units, then you cannot directly compare them unless they are continuum-removed. Some providers of remote sensing data also scale their data into certain ranges of values so that the data may be more efficiently stored. If that scaling factor is not known, then those data may have the same units but fall into different ranges than either your library spectra or some other image cube you wish to compare it to. This makes the data harder to compare, without continuum-removal. Remember that the fundamental methodology we'll use is to match a spectrum of our target with a spectrum from a library of spectra. It is the shape of the absorptions that matter, so comparing spectra of different scales can be done only after the kind of normalizing that continuum removal achieves.

Exercises

1. The values below represent a reflectance spectrum. Fill in the values for the spectral continuum at each wavelength as well as for the continuum-removed spectrum. Plotting the data in excel (or IDL/ENVI if you want to get fancy!) might help you figure out what the continuum should be.

Wavelength (microns)	Reflectance	Spectral Continuum	Continuum-removed Spectrum
0.5	0.08		
1.0	0.28		
1.5	0.48		
2.0	0.68		
2.5	0.88		
3.0	0.88		
3.5	0.58		
4.0	0.88		
4.5	0.88		
5.0	0.68		
5.5	0.18		
6.0	0.28		
6.5	0.08		

2. In ENVI, open the Landsat single-band image file *LT50130322002275LGS01_B7.tif* and display it in a new window. View a histogram of the data numbers (DNs), e.g. by clicking Enhance → Interactive Stretching… in ENVI Classic version.
   What are the minimum and maximum DN in this image?

   Describe the shape of the histogram. How many peaks does it have and what are their causes? What is the approximate DN range covered by each peak?

Without changing ENVI's default contrast/brightness stretch, locate Manhattan Island (centered at roughly 40°46' N, 73°58' W).

Is ENVI's default stretch the most useful way to view land surfaces such as this? Why or why not?

Create your own preferred stretch and save it as an image file. Email this file to me and briefly explain how it differs from the ENVI default.

3. Open the image file *qb_boulder_msi* in ENVI. This is a multispectral image of Boulder, CO from the QuickBird2 satellite owned and operated by DigitalGlobe. Using three of the available bands, display a "true-color" RGB image.

Which bands did you assign to each of R, G, and B?

Now locate this area in Google Earth.

What is the name of the irregular dark area in the right half of the image?

Next, in a new display window, display the 830 nm, 660 nm, and 560 nm data as R, G, and B, respectively. Link this window to your true-color display. Some areas in the new display window have a bright red color.

What are these bright red areas and why do they have this spectral character?